Table 11. Fillers Suitable for Silicone Polymers[a]

Filler	Particle size: Mean diameter, μm	Particle size: Surface area, m^2/g	Reinforcement produced in silicone gums: Tensile strength, MPa[b]	Reinforcement produced in silicone gums: Elongation, %
Reinforcing				
silica aerogel	0.03	110–150	4.1–6.9	200–350
fumed silica	0.015–0.02	175–200	4.1–12.4	200–600
acetylene black	0.045	78–85	4.1–6.2	200–350
Semireinforcing and nonreinforcing				
flux-calcined diatomaceous silica	1–5	< 5	2.7–5.5	75–200
calcined diatomaceous silica	1–5	< 5	2.7–5.5	75–200
calcined kaolin	1–5	< 5	2.7–5.5	75–200
precipitated calcium carbonate	0.03–0.05	32	2.7–4.1	100–300
ground silica	5–10		0.7–2.8	200–300
ground silica	1–10		0.7–2.8	200–300
ground silica	5		0.7–2.8	200–300
zinc oxide	0.3	3.0	1.4–3.5	100–300
iron oxide	<1		1.4–3.5	100–300
zirconium silicate			2.8–4.1	100–300
titanium dioxide	0.3		1.4–3.5	300–400

[a] Ref. 352.
[b] To convert MPa to psi, multiply by 145.

compound. In an early method the filler is treated with chlorosilanes or other reactive silanes, and the HCl or other reaction products are removed by purging the filler mass with an inert gas (354). Cyclic siloxane oligomers are now widely used to treat filler for silicone elastomers (350).

The extremely high surface silicas used as fillers present the same storage and handling problems as the fluffy carbon blacks. Typical bulk densities for fumed silicas as collected from the fuming operation are 32–80 kg/m^3. They can be increased to 160–240 kg/m^3 by mechanical compaction and deaeration, but even this density requires a large storage area for a reasonable working supply. Bulk shipping techniques continue to improve. Filler is frequently transported in bags, from which it may be fed to conveyors or sent to bulk storage. Semi-fluidized pneumatic transfer to and from specially designed rail cars and storage silos is practical, but requires attention to loss at the point of discharge. Automatic equipment for weighing the proper charge of filler to batch compounding systems can be adapted to handling low density silicas. From a safety standpoint, handling any finely divided filler requires respirators or dust masks. However, the fumed oxides are in the form of spheres of amorphous silica, which, in contrast to crystalline silica dust, are considered incapable of inducing silicosis (355).

Oligomers of polydimethylsiloxane can be polymerized in the presence of fillers. Uncatalyzed base compounds for both RTV and heat-curing elastomers can be made in this way. However, optimal properties still depend on conventional compounding (356).

RTV Rubbers. Room temperature vulcanizing (RTV) silicone elastomers are supplied as uncured rubbers with liquid or pastelike consistencies. They are based on polymers of intermediate molecular weights and viscosities, eg,

100–1,000,000 mm^2/s at 25°C. Curing is based on chemical reactions that increase molecular weights and provide cross-linking; catalysts ensure cure control. The RTV silicone rubbers are available in two modifications. The cure reactions of one-component products are triggered by exposure to atmospheric moisture. Those of two-component products are triggered by mixing the two components, one of which consists of or contains the catalyst; the two components are supplied separately.

Fluids with silanol end groups are employed for most one-component products (340). The most widely used products are cured by reactions involving acetoxysilanes (357–360).

$$HO[Si(CH_3)_2O]_nH + 2\ CH_3Si(CH_3CO_2)_3 \longrightarrow (CH_3CO_2)_2(CH_3)SiO[Si(CH_3)_2O]_nSi(CH_3)(CH_3CO_2)_2 + 2\ CH_3COOH$$

$$CH_3CO_2Si{\equiv} + H_2O \longrightarrow HOSi{\equiv} + CH_3COOH$$

$$CH_3CO_2Si{\equiv} + HOSi{\equiv} \longrightarrow {\equiv}SiOSi{\equiv} + CH_3COOH$$

Cure is accelerated and controlled by catalysts, especially tin soaps (361). In the above sequence methyltriacetoxysilane functions as a vehicle for polymer chain extension and cross-linking. Analogous products based on methyltris(2-ethylhexanoyloxy)silane are also available (362). Cure proceeds by hydrolytic cleavage of the acyloxy group from silicon, followed by condensation of the silanol group formed with another acyloxy silicon, and so on. Evaporation of the acid by-product drives the reaction toward completion. The tin catalyst probably functions by forming an active complex with polymer silanol, which reacts with the cross-linking agent (363,364).

Other cure systems proceed similarly, but employ different silane curing agents. Commercial products based on methoxysilanes and catalyzed by titanium compounds (eg, chelates) sometimes have the advantage of releasing a hydrolysis product that is not acidic (365–368). Other products employ methoxy-functional cures catalyzed by tin compounds; methanol scavengers can be used to protect the polymer from tin-catalyzed alcoholysis. Alkoxysilanes are slower cross-linking agents than acetoxysilanes. Promoters are sometimes employed to get sufficiently fast cures (369–372). Acetone is the by-product from methyltris(isopropenoxy)silane (373,374). Products based on amino-, amido-, and ketoxysilanes are also available (375–377).

The most common cross-linkers are trifunctional silanes. Tetrafunctional silanes provide faster cures; eg, cure times with tetraethoxysilane are shorter than with triethoxysilanes. Small multifunctional siloxane oligomer molecules can also be used, such as $[R_nX_{3-n}Si]_2O$, where n = 0–3, R is alkyl, and X is the reactive function (343,363). The fillers and additives used in these products must be compatible with the curing agent; that is, they must be dry.

The one-component RTV rubbers are made by mixing polymers, fillers, additives, curing agents, and catalysts. The mixture is packaged to protect it from moisture, which may trigger cure. The time required for cure depends on the curing system, temperature, humidity, and thickness of the silicone layer. Under

typical ambient conditions the surface can be tack free in 15–30 min; a 0.3-cm thick layer cures in less than one day. As cure progresses, strength develops slowly for about three weeks (340,378,379).

The original viscosity of these RTV materials depends principally on that of the polymer components and the filler loading. Filler and original polymer properties and cross-link density affect the ultimate strength of the fully cured elastomer; most commercial products are based on polydimethylsiloxanes. Polymers with substituents other than methyl modify and improve certain properties; eg, trifluoropropyl groups improve solvent resistance. Some products are compounded with fillers and additives to be pourable, and others to be thixotropic. Silica-filled polydimethylsiloxane systems, lacking pigments and other additives, cure to form translucent rubbers. Since the specific gravity of silicas (ca 2.2) exceeds that of siloxanes (ca 1.0), the specific gravity of the RTV rubbers depends on the filler loading. Physical properties of similar cured acetoxy RTV formulations are shown in Table 12 (380).

Table 12. Physical Properties of RTV Rubbers[a]

Specific gravity[b]	Durometer hardness, Shore A	Tensile strength, MPa[c]	Elongation, %
1.18	45	2.4	180
1.30	50	3.1	140
1.33	50	3.4	200
1.37	55	3.8	120
1.45	60	4.5	110
1.45	60	5.2	160
1.48	65	4.8	110

[a] Ref. 380.
[b] With increasing filler loading.
[c] To convert MPa to psi, multiply by 145.

Formulations with different curing systems, polymer molecular weights and structures, cross-link densitites, and other characteristics offer a broad spectrum of product properties. For example, one-component products are available with elongations as high as 1000%. Typical properties of representative cured RTV silicone rubbers are shown in Tables 13 and 14 (378,379,381–387).

Table 13. Cure Properties of Typical RTV Silicone Rubbers[a]

	One component		Two components	
Property	General purpose	Construction sealant	Adhesive sealant	Molding compound
hardness, Shore A, durometer	30	22	50	60
tensile strength, MPa[b]	2.4	1.0	3.4	5.5
elongation, %	400	850	200	220
tear strength, J/cm^2[c]	0.80	0.35	0.52	1.75

[a] Refs. 378, 379, 381–385.
[b] To convert MPa to psi, multiply by 145.
[c] To convert J/cm^2 to lbf/in., multiply by 57.1.

Table 14. Thermal and Electrical Properties of Cured Silicone Elastomers[a]

Property	Typical range
useful temperature range, °C	−60 to 200
with thermal stabilizers	−110 to 250
thermal conductivity, W/(m·K)	1.7–3.4
coefficient of thermal expansion, per °C	3.5×10^{-5}
dielectric strength, V/μm	20
dielectric constant at 100 Hz	3.5–4.5
dissipation factor at 100 Hz	0.01–0.02
volume resistivity, Ω·cm	10^{14}–10^{15}

[a] Refs. 378, 379, 381–387.

The one-component RTV silicone rubbers are mostly used in adhesive and sealant applications. Other uses include formed-in-place gasketing, protective coatings, and encapsulation; bonding properties are important. Many formulations provide self-bonding to most metals, glass, ceramics, concrete, and plastics. For example, bonds to aluminum with >1.38 MPa (200 psi) shear strength and 0.35 J/cm^2 (20 lbf/in.) tear strength are reported; good bonds are formed with copper and acrylic resins. Bonding can be improved by applying a primer to the substrate. These primers are solutions of reactive silanes or resins that dry (cure) on the substrate, leaving a modified silicone bondable surface. Bond strength develops as the RTV cure progresses and can require up to 2–3 weeks (362,388–391).

The two-component RTV silicone rubbers are available in a wide range of initial viscosities, from as low as an easily pourable 100-mm^2/s material to as high as the stiff pastelike materials of over 1,000,000 mm^2/s at 25°C (383). Curing system, polymer molecular weight and structure, cross-link density, filler, and additives can be varied and combined, giving a group of products whose properties cover a wider range than that encompassed by the one-component products. The highest strength RTV rubbers are provided by two-component RTV technology. On the other hand, products that cure to a mere gel are also available (392). Unfilled resin-reinforced compositions can provide optical clarity (393,394). Polymers with phenyl, trifluoropropyl, cyanoethyl, or other substituents can be used with or in place of polydimethylsiloxanes for low temperature-, heat-, radiation-, and solvent-resistant elastomers (67,383,395).

The two-component RTV silicone rubbers do not require atmospheric moisture to trigger cure. Several different curing systems are employed, with different advantages. For example, the silanol-terminated silicone polymer is treated with alkoxy-functional silicon curing agents:

$$3\ HO[Si(CH_3)_2O]_nH + CH_3Si(OC_2H_5)_3 \xrightarrow{\text{catalyst}} CH_3Si\{O[(CH_3)_2SiO]_nH\}_3 + 3\ C_2H_5OH$$

The catalyst is usually a tin salt. The product can be designed in such a way that the polymers and curing agent are in one package and the catalyst alone or the curing agent and the catalyst in the other. Cure is triggered by mixing the contents of the two packages. Fillers and additives are incorporated in the formulations according to the desired product properties (7,396).

In one example the polymers are mixed with filler and ethyl silicate as the curing agent. Dibutyl tin dilaurate catalyst is stirred in, and polymerization

begins immediately with the elimination of ethyl alcohol. The pot life and work life depend on temperature and catalyst type and concentration: pot life is a few hours at room temperature and can be prolonged by cooling. The time required to obtain a firm cure is approximately one day at room temperature and ca 1 h at 150°C (383). The cure rate is increased markedly with accelerators, such as 3-aminopropyltriethoxysilane (397).

The reaction of silanol-terminated silicone polymers with hydride-functional siloxanes is another route to RTV two-component products. The hydrogen gas generated as by-product can be used for foaming.

$$\equiv SiOH + HSi\equiv \xrightarrow[\text{salt}]{\text{tin}} \equiv SiOSi\equiv + H_2$$

When foaming is not desired, this type of product is usually restricted to thin films of RTV rubber (7).

Despite the commercial importance of products based on these RTV cure systems, little has been published concerning their chemistry. It has been shown that, in the RTV system involving silanols and ethyl silicate, ethanol evolves and siloxanes form; the reaction requires a tin compound initiator, which forms SiOSn compounds with ethyl silicate (398).

Hydrosilation curing gives two-component RTV rubbers without liberating a by-product. This cure system is based on the addition of silicon hydride to olefin. In practice, vinyl-functional silicone polymers are used with hydride-functional siloxanes as curing agent.

$$\equiv SiCH{=}CH_2 + HSi\equiv \longrightarrow \equiv SiCH_2CH_2Si\equiv$$

The reaction proceeds at room temperature in the presence of a catalyst, eg, chloroplatinic acid or another solubilized platinum compound. The hydrosilation cure of two-component RTV rubbers can be formulated in various ways. Fillers and additives are used according to the desired properties, but their character is restricted because of the sensitivity of platinum catalysts to poisoning. The catalyst is usually included with the vinyl-functional silicone polymers in the first package, and the hydride-functional siloxane curing agent, perhaps with additional vinyl polymers, in the second. The proportions used determine the ratio in which the two packages are mixed to give a cured elastomer with optimal properties. The pot life of these products is a few hours at room temperature (7,383,399).

Although in the other cure systems for RTV rubbers cross-links are established by the formation of new siloxane bonds by condensation reactions, this hydrosilation reaction creates ethylene bridges $\equiv Si{-}CH_2CH_2{-}Si\equiv$ between polymer chains. At room temperature, cure requires several days, but is usually run at higher temperatures (50–100°C). Control of the environment is important because the catalyst can be poisoned; water and alcohols react with Si—H in the presence of these catalysts: $\equiv SiH + H_2O \longrightarrow \equiv SiOH + H_2$. This reaction can also

be used to produce foamed rubber. Such materials, formulated for flame retardancy, are employed in wall construction to hinder the spread of fire.

The two-component RTV silicone rubbers are extensively used in encapsulating and molding applications, as well as for bonding, sealing, protective coatings, and electrical insulation. They afford longer work life and faster cures than the one-component products and are used in applications that require cure of thick sections. These cured RTV rubbers often do not adhere to other surfaces and are most suitable for fabricating flexible molds. They can be easily molded into various articles (340,383–385,388). Silicone elastomer emulsions made with hydrosilation-curing systems (latexes) are used for coatings (400).

The two-component RTV rubbers are less prone to self-bonding than the one-component materials; primers are applied where adhesion is needed. Lap-shear adhesion strengths exceeding 3.4 MPa (500 psi) have been reported on primed aluminum (389,390).

Batch equipment for RTV compounding includes vertical overlapping blade mixers with interchangeable bodies or cans, which can be lowered for product transfer or cleanout; they are called change-can mixers. Mixing cycles may be longer than in dough-mixer compounding since the lower viscosity polymers employed offer less resistance and delay the high shear necessary for deagglomeration of filler aggregates and good dispersion in the polymer. Compounding recipes differ from those for heat-cured rubber.

In one-component formulations that rely for cure on the reaction between a reactive cross-linking agent and atmospheric moisture, the ingredients must be thoroughly dried, or a drying step must be included in the compounding cycle. As more filler is added during compounding, the resistance to mixing tends to peak until "wetting-in" is reached. The moisture-sensitive cross-linking agent is usually added last; this step can be performed separately. When the uncatalyzed base compound and cross-linking agent are mixed, the effective viscosity sometimes passes through a maximum. As the early chemical interactions are resolved, the typical consistency is obtained. Allowance for elevated effective in-process viscosities must be made when mixing equipment is specified. Silica-reinforced uncatalyzed base compounds harden (develop structure) on storage, and the addition of catalyst should not be delayed.

Although formulations vary widely, a simple one-component acetoxysilane curing formulation might have the approximate composition given in Table 15. The silicone polymer may be a silanol-terminated polydimethylsiloxane with a viscosity of ca 10,000 mm^2/s (= cSt), fumed silica is the reinforcing filler, and dibutyl tin dilaurate is the catalyst. Lower molecular weight silanol-functional fluids provide process aids. Such fluids have viscosity values of less than 200 mm^2/s (= cSt) and may contain some branching; hydroxy group contents are between 0.1 and 8% (359).

For two-component formulations each part may contain varying proportions of filler and polymer. The second part contains the curing catalyst and possibly the cross-linking agent and pigments. By proper design of the compound, the proportions of first and second parts to be used may be adjusted for convenient handling and metering. (From 1 to 20 parts of the first part are typically used per part of the second.) Milling on a three-roll paint mill may be necessary to

Table 15. Acetoxysilane Curing Formulation

Component	Parts by weight
base	
silicone polymer	100
reinforcing filler	20
process aids	15
pigment	1
curing agent	
cross-linking methyltriacetoxysilane	5
catalyst	0.1

break down the last filler agglomerates, especially when sintered oxides or other hard fillers are used.

In continuous processing a devolatilizing extruder can be used to prepare RTV materials. The ingredients are incorporated at precise points in the production stream to obtain the desired degree of dispersion and chemical reaction. Base compounding and subsequent addition of catalyst for one-component formulations can be combined in one process. Special advantages are provided by systems that require unusually high shear mixing or that liberate substantial amounts of heat (401).

Continuous processing permits superior process control. A closed-loop process is illustrated in Figure 19. The feed rates of the ingredients can be monitored and adjusted to yield specific properties. The concentration of cross-linking agent, for example, can be continuously and automatically measured (402).

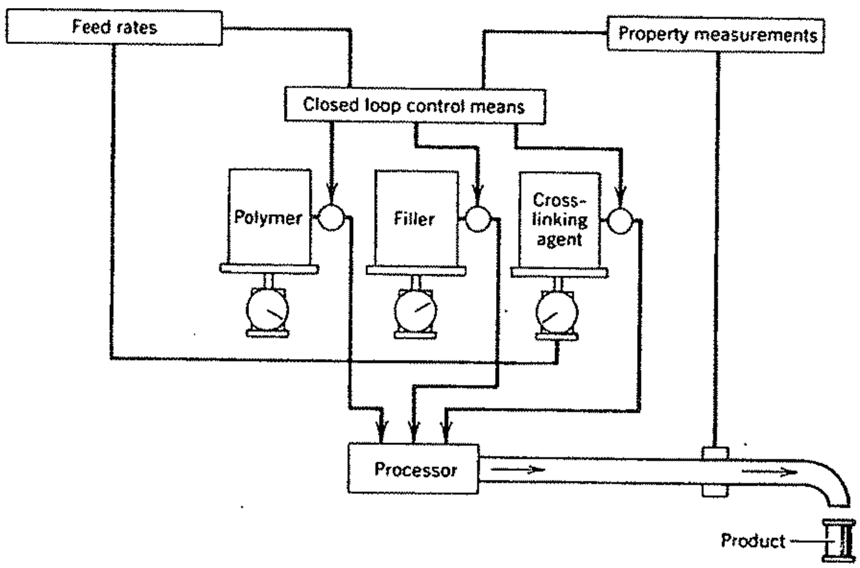


Fig. 19. Continuous one-component RTV processing. Adapted from Ref. 402.

The one-component RTV products are packaged in pails and drums with linings or seals to bar moisture. Many of these products are also packaged by automatic equipment into tubes and cartridges for dispensing by gun on assembly lines, in construction, or for home use.

Some two-component RTV products are sold as kits, in which the parts are formulated to afford the desired properties when used together. This is unnecessary when the second part contains only catalyst (383,385). Compounds that are packaged in hermetically sealed containers may be continuously deaerated by passing the compound as a thin film through an evacuated chamber. The two-component RTV products are packaged in cans, pails, and drums. Some curing agents are supplied in bottles or squeeze tubes.

New packaging materials and design innovations have made RTV products available in lighter, more economical, convenient containers; One Touch sealants from General Electric are easily dispensed from pressurized containers designed for consumer use, for example.

Heat-cured Rubbers. Many two-component RTV elastomers can be advantageously cured at 50–150°C, depending on the product and intended use, but RTV is characteristic. Hydrosilation-curing RTV compositions can be modified with inhibitors to become heat-curing systems. Some inhibitors are volatile vinyl or acetylenic compounds that are expelled at elevated temperatures, followed by cure. These volatile inhibitors may form vapor pockets that disrupt the integrity of the cured rubber and mar its surface. Examples include olefinic nitriles and acetylenic alcohols, which form complexes with the platinum catalysts that are ruptured by heat (280,403). Inhibitors such as triallyl isocyanurate release the catalyst at elevated temperatures, but are not volatile and are quickly incorporated into the cured elastomer (281). Such inhibited products are used in applications where long pot lives (10–1000 h), are needed after mixing the two packages and where the option of heat curing is available for a cure in less than 1 h, and often in minutes or seconds. Liquid injection molding, electronic potting, and coating operations are such applications.

Unlike RTV compositions, most heat-curing silicone rubbers are based on high molecular weight polymer gums. Gums, fillers, and additives are mixed in dough mixers or Banbury mills. Catalysts are added on water-cooled rubber mills, which can be used for the complete process in small-scale operations (67,404–406).

Silicone rubbers are commercially available as gums, filler-reinforced gums, dispersions, and uncatalyzed and catalyzed compounds; the last are ready for use. Dispersions or pastes are stirred with solvents such as xylene. The following types of gums are commercially available: general purpose (methyl and vinyl), high and low temperature (phenyl, methyl, and vinyl), low compression set (methyl and vinyl), low shrink (devolatilized), and solvent resistant (fluorosilicone); properties are shown in Table 16.

The tensile strength of cured dimethylsilicone rubber gum is only ca 0.34 MPa (50 psi). Finely divided silicas are used for reinforcement. Other common fillers include mined silica, titanium dioxide, calcium carbonate, and iron(III) oxide. Crystallizing segments incorporated into the polymer also serve as reinforcement. For example, block copolymers containing silphenylene segments, $-\!\!\left[(CH_3)_2SiC_6H_4Si(CH_3)_2O\right]_n\!\!-$, may have cured gum tensile strengths of 6.8–18.6 MPa (1000–2700 psi) (119).

[redacted]

Table 16. Properties of Silicone Gums[a]

Type	Density d^{25}, g/cm^3	T_g, °C	Williams plasticity[b]
$(CH_3)_2SiO$	0.98	−123	95–125
$CH_3(C_6H_5)SiO$	0.98	−113	135–180
$CH_3(CF_3CH_2CH_2)SiO$	1.25	−65	

[a] Refs. 319, 386, 387, and 407.
[b] ASTM D926.

Consistencies of uncured rubber mixtures range from a tough putty to a hard deformable plastic. Those containing reinforcing fillers tend to stiffen, ie, develop structure, on storage. Additives, such as water, diphenylsilanediol, dimethylpinacoxysilane, or silicone fluids, inhibit stiffening (353,408,409).

The properties of fabricated rubber depend on the gum, filler, catalyst, additives, and solvents and their proportions. A high filler content increases hardness and solvent resistance and reduces elongation. The properties also depend on the thoroughness of mixing and the degree of wetting of the filler by the gum. The properties change as cure progresses and are stabilized by devolatilization. They are affected by the environment and aging.

Before being used, silicone rubber mixtures are freshened. Catalyst is added, and the mixture is freshly milled on rubber mills until the components band into smooth continuous sheets that are easily worked. Specific or custom mixtures are prepared by suppliers for particular product applications; hundreds of formulations have been compounded. A formula is designed to achieve some special operating or processing requirement, and formulations are classified accordingly (Table 17) (352,386–388).

Bouncing putty is a mixture of polydimethylsiloxane polymer gum, boric acid, special additives, fillers, and plasticizers. It flows on slow application of pressure like a highly viscous liquid, but on shock it behaves like an elastic solid and may even shatter (410,411).

Silicone rubbers are cured by several mechanisms. For hydrosilation cure high molecular weight polymers (gums) with vinyl functionality are combined with fluid hydride-functional cross-linking agents. The catalyst, a soluble platinum compound, is added with an inhibitor to prevent cure initiation before heating (176). High strength and solvent-resistant products are based on this technology (412,413).

Silicone rubber is usually cured by heating the reinforced polymer with a free-radical generator, eg, benzoyl peroxide. The predominant mechanism for polydimethylsiloxane elastomers appears to be one in which hydrogen is removed from the methyl groups and the resulting free radicals couple to form $Si{-}CH_2CH_2{-}Si$ bridges:

$$(C_6H_5COO)_2 \longrightarrow 2\ C_6H_5COO\cdot$$

$$C_6H_5COO\cdot + (CH_3)_2SiO \longrightarrow \cdot CH_2(CH_3)SiO + C_6H_5COOH$$

$$2\ \cdot CH_2(CH_3)SiO \longrightarrow O(CH_3)SiCH_2CH_2Si(CH_3)O$$

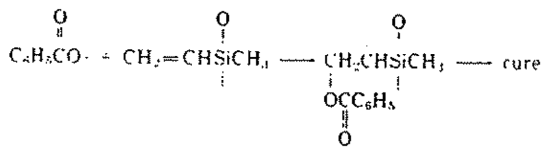
When the polymer contains vinyl groups (usually <1%), the peroxide radical

Table 17. Properites of Silicone Rubber Classes[a]

Class	Hardness, durometer	Tensile strength, MPa[b]	Elongation, %	Compression set at 150°C for 22 h, %	Useful temperature range, °C: Minimum	Useful temperature range, °C: Maximum	Tear strength, J/cm²[c]
general purpose	40–80	4.8–7.0	100–400	15–50	−60	260	0.9
low compression set	50–80	4.8–7.0	80–400	10–15	−60	260	0.9
extreme low temperature	25–80	5.5–10.3	150–600	20–50	−100	260	3.1
extreme high temperature	40–80	4.8–7.6	200–500	10–40	−60	315	
wire and cable	50–80	4.1–10.3	100–500	20–50	−100	260	
solvent resistant	50–60	5.8–7.0	170–225	20–30	−68	232	1.3
high strength flame retardant	40–50	9.6–11.0	500–700				2.8–3.8

[a] Refs. 352, 386–388.
[b] To convert MPa to psi, multiply by 145.
[c] To convert J/cm² to lbf/in., multiply by 57.1.

fragment adds to the double bond to give a radical that leads to cure:



The vinyl-based cure does not usually generate a benzoic acid by-product, which catalyzes decomposition or rearrangement of the siloxane polymer; it functions with less peroxide and works with peroxides that do not abstract hydrogen from methyl groups, eg, 2,5-dimethyl-2,5-di(*t*-butylperoxy)hexane (67,339).

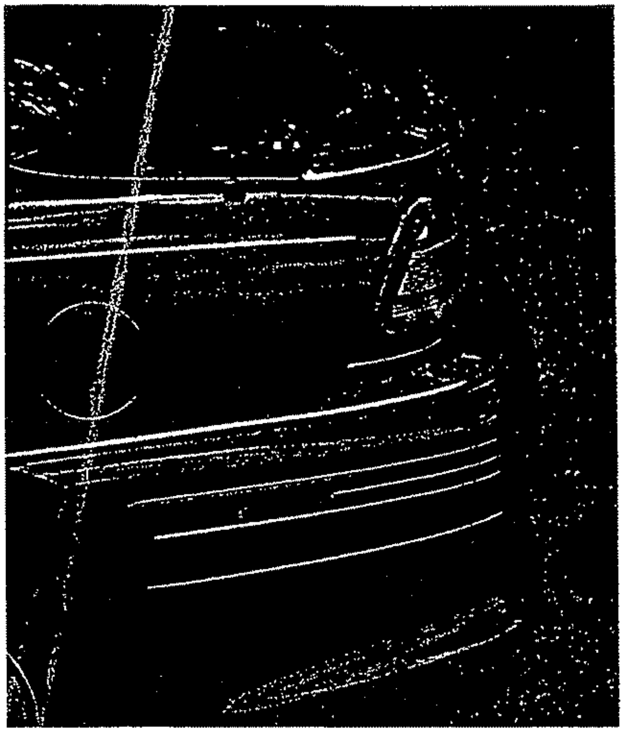
Benzoyl peroxide is most widely used for these cures. About 1.5–2 wt % is used for gums free of vinyl groups and ca 1 wt % for vinyl gums, based on the weight of gum; the curing temperature is ca 120°C. Bis(2,4-dichlorobenzoyl) peroxide, *t*-butyl peroxybenzoate, and dicumyl peroxide are used to obtain special effects. For example, bis(2,4-dichlorobenzoyl) peroxide permits rapid cure in air at 315°C without the development of porosity, which would be caused by the volatilization of lower boiling catalysts (342). Chlorobenzoyl peroxides give chlorobiphenyl by-products (275).

Cure is also effected by gamma or high energy electron radiation, which causes scission of all types of bonds, including Si—O; the important cure reactions are those involving Si—C and C—H. Hydrogen, methane, and ethane evolve, and bridges between chains are formed by recombination of the radicals generated. These bridges include Si—CH_2—Si, Si—Si, and perhaps Si—CH_2CH_2—Si (414). An absorbed dose of 770–1300 C/kg (3×10^6 to 5×10^6 roentgen) is required for effective cure; no acidic fragments remain in the polymer. Radiation cure can be used for thick sections, but high energy electrons penetrate to a depth of only a few millimeters (352).

Freshly mixed silicone rubber compounds are usually molded at 100–180°C and 5.5–10.3 MPa (800–1500 psi). Under these conditions thermal cure can be completed in minutes. The molds are usually lubricated with a 1–2 wt % aqueous solution of a household detergent. In the manufacture of insulated wire, rods, channels, tubing, and similar products, the compounds are extruded in standard rubber-extrusion equipment. The extruded rubber is heated briefly to set its properties; hot-air vulcanization at 300–450°C or steam at 0.28–0.70 MPa (40–100 psi) for several minutes is sufficient. Final properties can be developed by oven curing or by continuous steam vulcanization.

For coating silicone rubber on a fabric, eg, glass cloth, a dispersion in a solvent is employed. The cloth may be dip-coated and dried and cured in heated towers. It may also be calendered with high penetration, soft silicone stocks on standard three- and four-roll calenders. Ducts and hoses can be built up from dip-coated or calendered cloth, and complex structures can be formed on mandrels, followed by extrusion or by wrapping and curing to produce large ducts. Silicone rubber sponges are made with the help of nitrogen blowing agents, which produce a closed-cell structure; densities of foam or sponge are between 0.4 and 1.0 g/cm^3.

For bonding silicone rubber to other materials, eg, metals, ceramics, or plastics, primers are used, including silicate esters, silicone pastes, silicone resins,



MOLD CONSTRUCTION TECHNIQUES

As previously mentioned, final part geometry generally influences the mold-construction technique. This section discusses several of the most-common construction methods.

Milled Block

In this construction technique, the mold cavity is machined directly into a metal block. Although it may be more costly, a milled-block mold gives the most accurate representation of the part, does not show lines where the mold parts meet, and incorporates cooling lines easily; however, they are more difficult to modify.

Structural Components

Milled metal plates are joined with screws or pins, or welded in this construction technique. Joined plate and bar is the method of choice for large, flat parts.

Cast

Widely used in mold making, cast molds are relatively inexpensive. They make excellent molds and are used particularly for curved parts. Steel molds are not normally cast. Surface porosity, often just under the skin, can cause difficulties when polishing cast aluminum molds. To make a mold casting, a positive pattern with a predetermined parting line is made. This pattern is then cast. Afterwards, the surface is conditioned to remove bubbles and imperfections. Cooling lines can be cast into the mold.

Extruded Aluminum Profiles

Used for both solid and foamed systems, extruded profiles find special application in building inexpensive molds for profile geometries such as window frames or door sashings.

Nickel Plating

Nickel plating can be formed either electrolytically or by electroless deposition. In this latter technique, a 0.04- to 0.08-inch layer of nickel is deposited on a positive pattern, with a 3/8- to 1/2-inch copper backup layer electrolytically deposited onto the nickel. Cooling lines can also be plated onto this backup layer.

SURFACE TREATMENTS FOR MOLDS

Because RIM polyurethane systems reproduce fine surface details, the type of finish on a mold surface is critical. Consider using plastic-industry standards such as the SPI-SPE Mold Finish Comparison Kit, available from the Society of Plastics Industry, as a guideline.

Chrome and nickel plating, excellent surface treatments for molds, improve the mold's scratch resistance and reduce necessary demolding forces. Chrome plating gives better results. Before plating any mold surface, closely examine it to ensure that it is smooth and nonporous.

Other treatments such as Teflon coating or a nickel-polymer coating are used to improve mold release properties. Surface hardening methods — such as nitride — can minimize minor damage and the effects of abuse during production operations.

Depending upon your part's surface specifications, consider using the following finishes:

- No. 2 Grit (#15 micron range)
- No. 3 320 Emery Cloth
- No. 4 280 Stone

For cosmetic surfaces, consider using a finish between No. 2 and 3; for noncosmetic surfaces, a finish between 3 and 4 should suffice.

TEXTURES AND FINISHES

Lettering, textures, and graphics can be molded into a part. Typically these visual elements are milled into the mold resulting in a raised appearance on the finished part. For large areas of fine text, consider using decals.

Textures enlarge the effective surface area, requiring increased demolding forces. Surfaces parallel to the direction of draw have lower limits on texture depth.

Nickel shells offer high surface hardness and good release characteristics for high-quality surface reproductions of textures, such as leather or wood grain.

Photo-etching and mechanical texturing offer a wide variety of finishes. In photo-etching, chemicals etch mold surfaces in a given pattern. Some mold makers have examples with different textures to help you select one. In mechanical texturing, small metal balls are placed in the mold, which is then shaken, to achieve a pebble finish.

Before applying any texture to a mold surface, ensure that the mold is to final dimensions, because these dimensions cannot be changed after texturizing. Textures in molds must be very accurate, as the parts cannot be retouched after molding. These molds are very sensitive to nicks and scratches, requiring special care during demolding.

TECHNICAL SUPPORT

HEALTH AND SAFETY INFORMATION

Appropriate literature has been assembled which provides information concerning the health and safety precautions that must be observed when handling Bayer thermosetting resins mentioned in this publication. Before working with any of these products, you must read and become familiar with the available information on their hazards, proper use, and handling. This cannot be overemphasized. Information is available in several forms, e.g., material safety data sheets and product labels. Consult your local Bayer representative or contact the Product Safety Manager for Polymers Division products in Pittsburgh, PA.

DESIGN AND ENGINEERING EXPERTISE

To get material selection and/or design assistance, just write or call your Bayer representative in the regional offices listed on the back cover of this brochure. To best help you, we will need to know the following information:

- Physical description of your part(s) and engineering drawings, if possible
- Current material being used
- Service requirements, such as mechanical stress and/or strain, peak and continual service temperature, types and concentrations of chemicals to which the part(s) may be exposed, stiffness required to support the part itself or another item, impact resistance, and assembly techniques
- Applicable government or regulatory agency test standards
- Tolerances that must be held in the functioning environment of the part(s)
- Any other restrictive factors or pertinent information of which we should be aware

Upon request, Bayer will furnish such technical advice or assistance it deems to be appropriate in reference to your use of our products. It is expressly understood and agreed that because all such technical advice or assistance is rendered without compensation and is based upon information believed to be reliable, the customer assumes and hereby releases Bayer from all liability and obligation for any advice or assistance given or results obtained. Moreover, it is your responsibility to conduct end-use testing and to otherwise determine to your own satisfaction whether Bayer's products and information are suitable for your intended uses and applications.

TECHNICAL SUPPORT

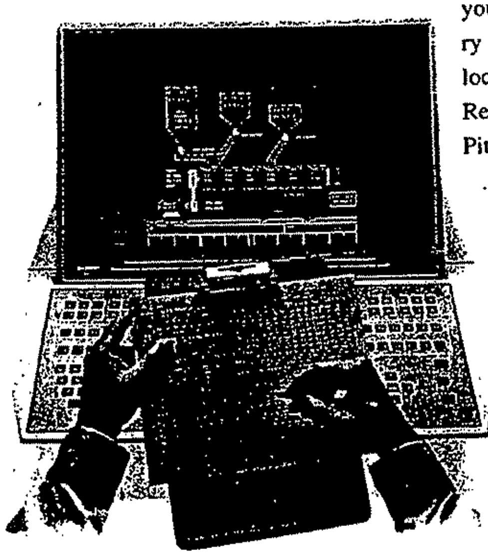
We provide our customers with design and engineering information in several ways: Applications and processing advice, available by phone, at 412 777-2000; processing assistance, through a nationwide network or regional field technical service representative (see list on back cover); technical product literature; and periodic presentations and seminars. The types of expertise you can obtain from Bayer include those listed in this section.

Design Review Assistance

- Concept development
- Product/part review
- Mold design review
- Part failure analysis
- Finite element stress analysis
- Mold filling analysis
- Experimental stress analysis
- Shrinkage and warpage analysis

Application Development Assistance

- Product development
- Part cost estimates
- Color matching
- Prototyping
- Material selection
- Molding trials
- Physical testing
- Secondary operation advice



Product Support Assistance

- On-site processing audits
- Start-up assistance
- On-time material delivery
- Troubleshooting
- Processing/SPC Seminars
- Productivity audits

REGULATORY COMPLIANCE

Some of the end uses of the products described in this publication must comply with applicable regulations, such as the FDA, USDA, NSF, and CPSC. If you have any questions on the regulatory status of these products, contact your local Bayer representative or the Regulatory Affairs Manager in Pittsburgh, PA.

RIM PLASTICS RECYCLING

Polyurethanes are now being recycled. Recycled polyurethanes have practical uses, like housings for electronic equipment and exterior body parts for transportation vehicles.

- **Regrinding**—This technology allows for a "second life" for many types of polyurethane parts such as business machines and bumpers, which are then ground into a granulate or powder for use as a filler.
- **Adhesive Pressing**—Polyurethane granulate is surface treated with a binder, then cured under heat and pressure. The resulting materials can be reinforced and molded.
- **Compression Molding**—This technique allows for 100% reuse of RIM polyurethane elastomers in which no virgin material needs to be added. Can retain up to 50% of tensile properties.
- **Energy Recovery**—Technology exists to pyrolyze polyurethane polymers cleanly, and the combustion products can meet EPA standards. One pound of RIM polyurethane contains between 12,000 and 15,000 BTUs, about the same energy potential as oil or coal.
- **Injection Molding**—This process is suitable for composite components, such as instrument panels that contain a thermoplastic support, foam, and decorative skin. The entire module can be ground and injection molded.
- **Glycolysis**—This is a chemical recycling process in which the polymer is broken down into a mixture of liquid polyols. Many different kinds of polyurethane parts can be used.

Polyurethanes. They do a world of good when you use them. And when you reuse them.

FOR MORE INFORMATION

The data presented in this brochure are for general information only. They are approximate values and do not necessarily represent the performance of any of our materials in your specific application. For more detailed information, contact Polymer Marketing Communications at 412 777-2000, or your nearest district office.

Appendix

LIST OF FIGURES AND TABLES

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MATERIAL SELECTION CRITERIA

Chapter 2

GENERAL PART DESIGN

Chapter 2

GENERAL PART DESIGN *continued*

Chapter 3

SOLID MATERIALS

Chapter 4

FOAMED MATERIALS

Chapter 5

COMPOSITE MATERIALS

Chapter 6

POSTMOLDING OPERATIONS

INDEX

Bayer

Polyurethanes

Quick Design Reference Guide for RIM Materials

	Elastomers	Rigid RIM			Composites	
Parameters	Solid Bayflex System (Unfilled)	Foamed Baydur System	Solid Baydur GS System	Solid PRISM System (Thin-Walled)	Foamed Baydur STR/F System	Solid Baydur STR/C System

Part Design

Parameters	Solid Bayflex System (Unfilled)	Foamed Baydur System	Solid Baydur GS System	Solid PRISM System (Thin-Walled)	Foamed Baydur STR/F System	Solid Baydur STR/C System
(t) Wall Thickness (in)	0.2 – 1.0	0.2 – 1.5	0.25 – 1.0	0.125 – 0.5	0.125 – 0.25	0.09 – 0.15
Rib Thickness, at Root[a]	0.75t	t	t	0.75t	Use box beam or corrugation	Use box beam or corrugation
Draft (degrees) This is Function of Part Draw or Depth	0.5 min. 0.25/inch greater than one inch of draw	0.5 min. 0.25/inch greater than one inch of draw	0.5 min. 0.25/inch greater than one inch of draw	0.5 min. 0.25/inch greater than one inch of draw	1.0 min.	1.0 min.
Molded Holes/Slots	Yes	Yes	Yes	Yes	No	No
Undercuts	Slight undercuts	Use side pull or removable insert	Use side pull or removable insert	Use side pull or removable insert	No	No
Snap Fits	Possible	Possible	Possible	Possible	No	No
Fillets (Inner Radius) (in)	1/16	1/8	1/8	1/16	1/4	[illegible]

Finishing

Parameters	Solid Bayflex System (Unfilled)	Foamed Baydur System	Solid Baydur GS System	Solid PRISM System (Thin-Walled)	Foamed Baydur STR/F System	Solid Baydur STR/C System
Best Surface	Class A	Class A	N/A	Class A	No Class A, use texture	Class A with veil
Screw Assembly	Use bolt & nut[b]	Thread cuts skin	Thread cutting	Thread cutting	Thread cutting	Thread cutting

Mold Design and Processing Parameters

Parameters	Solid Bayflex System (Unfilled)	Foamed Baydur System	Solid Baydur GS System	Solid PRISM System (Thin-Walled)	Foamed Baydur STR/F System	Solid Baydur STR/C System
Material of Construction	Metal preferred (depending on prod. volume)	Metal preferred (depending on prod. volume)	Metal preferred (depending on prod. volume)	Metal preferred (depending on prod. volume)	Steel	Steel
Preferred Gating	Fan	Dam	Dam	Dam	Center/Direct	Center/Direct
Shot Time, Max. (sec)	3[c]	[illegible]	15	5	5	5
Mold Pressure (psi)	100	100	100	100	200	200
Mold Temperature (°F)	140 – 160	110 – 160	140 – 160	110 – 160	[illegible]	175 – 185

Physical Properties

Parameters	Solid Bayflex System (Unfilled)	Foamed Baydur System	Solid Baydur GS System	Solid PRISM System (Thin-Walled)	Foamed Baydur STR/F System	Solid Baydur STR/C System
Flexural Modulus (psi)	5,000 – 100,000	53,000 – 240,000	180,000 – 190,000	270,000 – 310,000	150,000 – 750,000	Up to 2,000,000
Part Density (lb/in^3)	60 – 65	15 – 55	63 – 68	61 – 67	20 – 40	90 – 110
Flexural Strength (psi)	N/A	3,000 – 12,000	5,300 – 7,700	9,200 – 10,500	3,500 – 17,000	50,000
Tensile Strength (psi)	1,900 – 4,000	1,000 – 4,800	3,600 – 5,300	5,500 – 6,600	2,500 – 9,000	26,000
Elongation at Break (%)	100 – 350	[illegible]	16 – 29	11 – 12	2.5	2.5
DTUL at 66 psi (°F)	N/A	160 – 212	140 – 215	190 – 205	205	400
Hardness (Shore D)	[illegible]	[illegible]	70 – 75	71 – 75	60 – 70	60 – 70
% Reinforcement	0 – 25	N/A	N/A	N/A	20 (mat)	55 (mat)

[a]Root includes both radii. [b]Can also screw through to metal substrate.

[c]Longer shot times are possible with a Bayflex XGT system, which has an extended gel time.

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Bayer

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Illinois:	9801 W. Higgins Road, Suite 560, Rosemont, IL 60018-4704 708 692-5560 • Fax: 708 692-7408
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Bayer

Engineering Polymers

Properties Guide

THERMOPLASTICS
AND
POLYURETHANES

Thermoplastics from Bayer

The Polymers Division of Bayer Corporation supplies engineering thermoplastics and polyurethanes, technology, and equipment for a wide range of applications and industries.

Thermoplastics

The Plastics Department offers an extensive range of engineering thermoplastic resins and specialty plastics. In addition to the products listed in this brochure, polycarbonate films and thermoplastic urethane films are also available.

For information, please call 1-800-622-6004.

Products	Features
MAKROLON® Polycarbonate Pages 8-11	Glass-like transparency Outstanding impact strength Good thermal resistance Excellent dimensional stability Good electrical properties
APEC® High-Heat Polycarbonate Page 11	Glass-like transparency High deflection temperature under load High impact strength Excellent dimensional stability
BAYBLEND® and **TRIAX®** Polycarbonate/ABS Blend Pages 12-13	Good impact resistance even at low temperatures Rigidity and dimensional stability Easy processing Good color stability to indoor lighting Good thermal stability
MAKROBLEND® Polycarbonate Blend Pages 14-15	Good chemical resistance Excellent impact resistance even at low temperatures Good abrasion resistance Good processibility and thermal stability Rigidity and dimensional stability
TRIAX® Polyamide/ABS Blend Page 15	High impact strength Excellent abrasion characteristics Good chemical resistance and fatigue performance State-of-the-art blending technology Excellent processing characteristics
LUSTRAN® ABS Pages 16-17	Toughness, strength, and rigidity Heat and chemical resistance Dimensional stability and creep resistance Good surface appearance Good processibility

Thermoplastics from Bayer

Grades	Markets and Applications[a]
General-Purpose High-Productivity Impact-Modified Glass-Reinforced Flame-Retardant Structural Foam Extrusion Medical Optical Lighting Automotive Lens	**Automotive and Transportation**: forward and rear lighting components, instrument panels, aircraft canopies **Building and Construction**: extrusion resin for monolayer and structured sheet, profiles **Business Machines**: computer and printer housings, sight windows **Consumer**: power tool housings, food storage containers, appliances, sporting goods **Electrical/Electronic**: electric meter covers, telephone components, lighting diffusers and lenses [b]**Medical**: diagnostic, cardiovascular and intravenous devices; drug delivery systems; packaging **Optical**: lenses for prescription eyewear, sunwear, industrial safety glasses and specialty eye protection **Optical Memory**: audio and video compact discs, data storage discs **Packaging**: bottles, film
General-Purpose Flame-Retardant Medical	**Automotive and Transportation**: reflectors, lenses, and light pipes for interior and exterior lighting **Consumer**: steam iron water tanks, hair dryer components, microwave oven doors, gas range controls and ignition switches **Electrical/Electronic**: fuses, switch housings; lighting reflectors, diffusers and lenses **Industrial/Mechanical**: emergency equipment, face shields, indicator lenses [b]**Medical**: packaging, surgical lighting, autoclavable devices
General-Purpose High-Productivity Glass-Reinforced Flame-Retardant Structural Foam Extrusion and Blow Molding Plating	**Automotive**: interior and exterior parts, wheel covers, instrument panels **Business Machines**: computer, monitor and printer housings; general office equipment **Consumer**: household appliances, smoke detectors, lawn and garden equipment **Electrical/Electronic**: modular plugs, wiring devices
Impact-Modified Glass-Reinforced Flame-Retardant [c]FDA-Compliant Transparent	**Automotive**: body panels, bumpers, interior switches, exterior mirror housings **Consumer**: appliances, food trays, household cleaning equipment, lawn and garden equipment, sporting goods, telecommunications equipment **Electrical/Electronic**: connectors, electrical housings, interrupters, switch housings **Industrial/Mechanical**: meter housings, pump housings, agricultural equipment
General-Purpose Glass-Reinforced Extrusion	**Automotive**: interior functional components, fasteners, housings and shrouds **Consumer**: appliances, lawn and garden equipment, power tools, sporting goods
Molding High-Gloss Low-Gloss High-Impact High-Heat Extrusion Medical Clear	**Automotive**: interior and exterior trim, pillar posts, consoles, scuff plates, map pockets **Business Machines**: keyboard keys, computer housings and bezels **Consumer**: housewares, small appliance housings, floor care components, lawn and garden appliances, power tool housings, toys, telecommunications equipment, consumer electronics **Industrial/Mechanical**: drain, waste and vent pipe and fittings [b]**Medical**: drug delivery systems, diagnostic equipment and instruments, test kits **Packaging**: cosmetic containers **Sheet and Profile**: custom extruded products

[a] As with any product, use of a particular resin in a given application must be tested (including field testing, etc.) in advance by the user to determine suitability.
[b] Please refer to Bayer Corporation guidelines for medical application of Bayer products on pages 4-5.
[c] Makroblend DP4-1370 resin (natural color) can be used for food-contact applications except for those in which the temperature exceeds 250°F and the food contains more than 50% alcohol. Since color possibilities for food-contact applications are limited, please contact your Bayer representative for information on available colors and their limitations.

Thermoplastics from Bayer

(continued)

Thermoplastics

The Plastics Department offers an extensive range of engineering thermoplastic resins and specialty plastics. In addition to the products listed in this brochure, polycarbonate films and thermoplastic urethane films are also available.

For information, please call 1-800-622-6004.

Products	Features
LUSTRAN® SAN Page 18	Glass-like clarity Strength and rigidity Excellent chemical resistance Heat and abrasion resistance Easy processing
CADON® SMA Pages 18-19	High heat resistance Impact strength Rigidity Good chemical resistance
CENTREX® ASA, AES and ASA/AES Weatherable Polymers Page 19	Toughness and durability Resistance to fading and cracking from sunlight and temperature extremes Resistance to road chemicals Light weight
DURETHAN® Polyamide 6 Pages 20-23	High strength, rigidity and hardness Excellent toughness and impact resistance High dynamic fatigue resistance Excellent abrasion and chemical resistance High heat resistance in reinforced grades Good electrical insulating properties
TEXIN® and **DESMOPAN®** Thermoplastic Polyurethane Pages 24-25	Excellent abrasion resistance Excellent resistance to fuels and oils High tensile and tear strength High elasticity and resilience Good vibration dampening Shore hardness range from 85A to 75D

[a] As with any product, use of a particular resin in a given application must be tested (including field testing, etc.) in advance by the user to determine suitability.
[b] Please refer to Bayer Corporation guidelines listed below for medical application of Bayer products.

Bayer Corporation Guidelines for Medical Application of Bayer Products

1. All Bayer resins, films, etc. [hereinafter "Product(s)"] designated as "medical-grade" have met the requirements of the FDA-Modified ISO 10993, Part I "Biological Evaluation of Medical Devices" tests with human tissue contact time of 30 days or less. ONLY THESE PRODUCTS MAY BE CONSIDERED CANDIDATES FOR APPLICATIONS REQUIRING BIOCOMPATIBILITY. No "medical-grade" Product will be available for sale until successful completion of testing.
2. Regrind resins must not be used in medical applications requiring biocompatibility.
3. It is the responsibility of the medical device, biological product or pharmaceutical manufacturer ("Manufacturer") to determine the suitability of all component parts and raw materials, including any Bayer Product, used in its final product in order to ensure safety and compliance with FDA requirements. This determination must include, as applicable, testing for suitability as an implant device and suitability as to contact with and/or storage of human tissue and liquids including, without limitation, medication, blood or other bodily fluids.
4. Under no circumstances may any Bayer Product be used in any cosmetic, reconstructive or reproductive implant applications. Nor may any Bayer Product be used in any other bodily implant applications, or any applications involving contact with or storage of human tissue, blood or other bodily fluids, for greater than 30 days, based on the FDA-Modified ISO 10993 tests. Furthermore, for aromatic grades of Texin resins, such longer-term uses are not permissible also because possible hydrolysis of solid polyurethane may produce aromatic amines, such as methylene dianiline (MDA).

Thermoplastics from Bayer

(continued)

Grades	Markets and Applications[a]
General-Purpose High-Clarity High-Performance	**Consumer:** food and beverage containers, dinnerware, housewares, appliances, interior refrigerator components, toys **Industrial/Mechanical:** fan blades, filter housings [b]**Medical:** tubing connectors and valves, labware, urine bottles **Packaging:** cosmetic containers and displays
High-Heat Glass-Reinforced Extrusion	**Automotive:** interior and exterior trim, instrument panels **Consumer:** appliances, power tools **Industrial/Mechanical:** machinery parts
General-Purpose Gloss-Retention Extrusion	**Automotive:** interior trim, exterior and aftermarket parts **Consumer:** lawn and garden tractor components; boat and marine accessory parts; spa shells; swimming pool steps, covers and filter housings; golf accessories **Miscellaneous:** outdoor signs **Specialty Transportation:** recreational vehicle exterior parts
Unreinforced Impact-Modified Glass-Reinforced Mineral-Reinforced Mineral/Glass-Reinforced Reduced-Moisture and Impact-Modified versions of Glass-Reinforced and Mineral-Reinforced grades are available. Film grades available (not listed in table).	**Automotive:** interior and exterior parts, door handles, mirrors, wheel covers **Consumer:** furniture, lawn and garden equipment, power tool housings, sporting goods **Electrical/Electronic:** wiring devices, switch housings, fuse holders **Industrial/Mechanical:** pumps, fans, pneumatic tools, housings **Packaging:** film for packaging of food, chemicals, medical and industrial goods
Polyester Polyether Polyurethane/Polycarbonate Blends Medical Extrusion	**Automotive:** cams, gears, mechanical parts, exterior applications, side body molding **Building and Construction:** extrusion resins for film and sheet **Consumer:** golf balls, ski goggle frames, shoe components, ski boots **Industrial/Mechanical:** mine screens, animal identification tags, hydraulic seals, hoses, caster wheels, grain buckets [b]**Medical:** diagnostic devices, tubing and catheters, connectors

5. The suitability of a Bayer Product in a given end-use environment is dependent upon various conditions including, without limitation, chemical compatibility, temperature, part design, sterilization method, residual stresses or external loads. It is the responsibility of the Manufacturer to evaluate its final product under actual end-use requirements and to adequately advise and warn purchasers and users thereof.
6. Single-use medical devices made from a Bayer Product are not suitable for multiple uses. If the medical device is designed for multiple uses, it is the responsibility of the Manufacturer to determine the appropriate number of permissible uses by evaluating the device under actual sterilization and end-use conditions and to adequately advise and warn purchasers and users thereof.
7. The sterilization method and the number of sterilization cycles a medical device made from a Bayer Product can withstand will vary depending upon type/grade of Product, part design, processing parameters, sterilization temperature and chemical environment. Therefore, the Manufacturer must evaluate each device to determine the sterilization method and the number of permissible sterilization cycles appropriate for actual end-use requirements and must adequately advise and warn purchasers and users thereof.
8. Parts molded or extruded from Texin resins are sterilizable using ethylene oxide, radiation or dry heat. Steam autoclaving and boiling water techniques are possible only with select aliphatic grades of Texin resin. These sterilization methods must not be used with aromatic grades of Texin resin because possible hydrolysis may produce aromatic amines, such as methylene dianiline (MDA).

Polyurethanes from Bayer

Polyurethanes

The Polymers Division produces polyurethane raw materials and systems for the automotive, appliance, construction and furniture industries, as well as many other markets, such as consumer, industrial/mechanical, medical, and specialty transportation. In addition to the specialty systems listed in this brochure, the Polyurethanes Department offers integral skin foams; elastomeric, microcellular soling systems for the production of shoe soles; and semirigid, high-resilience and energy-absorbing foams. Moreover, a full range of raw materials and additives include diphenylmethylene diisocyanate (MDI), toluene diisocyanate (TDI), and polyols. A complete line of equipment for polyurethane processing is produced by the division's Hennecke Machinery Group.

For information, please call 1-800-622-6004.

Products	Features
BAYDUR® Structural Foam Polyurethane RIM Systems Pages 26-27	Two-component, MDI-based liquid systems Large-part moldability Stiffness High-gloss finish and excellent surface quality In-mold coating Used for thick- and thin-wall parts
BAYDUR® SFR Composite Polyurethane RRIM Systems Page 27	Two-component, MDI-based liquid systems Light weight High strength-to-weight ratio Excellent adhesion to fabric and vinyl
BAYDUR® STR Composite Polyurethane SRIM Systems Page 27	Two-component, MDI-based liquid systems Exceptional impact strength and stiffness Used for large structural parts
BAYDUR® GS Solid Polyurethane RIM Systems Page 27	Two-component, MDI-based liquid systems Excellent chemical resistance Stiffness Large-part moldability
PRISM® Solid Polyurethane RIM Systems Page 27	Two-component, MDI-based liquid systems Stiffness and high strength-to-weight ratio Good heat deflection temperature Excellent surface quality
BAYFLEX® Elastomeric Polyurethane RIM Systems Pages 28-29	Two-component, MDI-based liquid systems Large-part moldability Wide range of flexural moduli Superior impact strength Excellent surface quality and in-mold coating
BAYTEC® SPR Elastomeric and Structural Polyurethane Spray Systems Page 30	Two-component, MDI-based liquid spray systems Low-viscosity, solvent-free liquids (negligible VOCs) Used for structural parts or elastic membranes Good adhesion to substrates Fast cure times for ease in building laminates
BAYTEC® RTM Polyurethane Systems for Resin Transfer Molding Page 30	Two-component, MDI-based liquid systems Low-viscosity, solvent-free liquids (negligible VOCs) Outstanding impact resistance at high and low temperatures, with and without glass Fast reaction times and high flexural modulus
BAYTEC® Polyurethane Prepolymers for Cast Elastomers Page 31	MDI-based prepolymers Dynamic load-bearing ability Outstanding resilience and tear resistance Corrosion and abrasion resistance Flexible over a wide temperature range

Polyurethanes from Bayer

Grades	Markets and Applications[a]
General-Purpose Flame-Retardant	**Agricultural/Construction Equipment:** tractor cab roofs and consoles **Automotive:** aftermarket spoilers **Construction:** window and door frames **Consumer:** speaker housings, snow and water skis **Electrical/Electronic:** instrumentation and equipment housings, Nema 1 and 12 enclosures, telecommunications equipment **Medical:** analytical and diagnostic equipment housings **Specialty Transportation:** interior components for heavy trucks (Class 8)
Low-Density	**Automotive:** interior door panels, interior trim, sunshades
Low-Density High-Density	**Automotive:** bumper beams, inner door panels, interior trim, instrument panels, rear package trays, seat backs, seat pans
General-Purpose	**Industrial/Mechanical:** pump housings, underground applications (concrete and cast iron replacement) **Telecommunications:** utility boxes
General-Purpose Flame-Retardant	**Electrical/Electronic:** telecommunications equipment, instrumentation and equipment housings **Medical:** analytical and diagnostic equipment housings, laboratory instrumentation
Unfilled Glass-Filled Mineral/Microsphere-Filled	**Agricultural/Construction Equipment:** hay conditioning rollers, tractor body panels and door frames **Automotive:** fascias, body panels, window encapsulation, aftermarket restyling packages **Specialty Transportation:** heavy-duty truck bumpers, snowmobile hoods, work vehicles
Elastomeric Structural	**Automotive:** aftermarket restyling packages **Consumer:** on-deck marine accessories, spas and bathtubs **Industrial/Mechanical:** industrial liners, dump truck liners, containers, agricultural parts **Miscellaneous:** protection for wood, metal, and concrete
General-Purpose	**Automotive:** aftermarket restyling packages **Consumer:** marine accessories, radar dishes **Industrial/Mechanical:** pump housings, valve bodies, fan blades **Specialty Transportation:** components for heavy trucks, recreational vehicles, tractors, and construction vehicles
Polyester Poly(tetramethylene ether) glycol Poly(propylene ether) glycol	**Industrial/Mechanical:** tires and wheels, rolls, hydrocyclones, pipeline pigs, seals and gaskets, gears and sprockets, die-cut pads and chopper cots, belts, liners, classifier screens, conveyor belt scrapers, shock absorbers

[a] As with any product, use of a particular polyurethane system in a given application must be tested (including field testing, etc.) in advance by the user to determine suitability.

CW 0308775

Skis abrasion

Bayflex®

Polyurethane Elastomeric RIM

POLYURETHANES			MP-5000	MP-10000	110 RIM-Lite	110-25 IMR	110-50		
Typical Physical Properties*	ASTM Test Method (Other)	U.S. Conventional Units	Unfilled	Unfilled	13% Mineral[1]	Unfilled	Unfilled	15% Mineral[2]	15% Glass[3]
GENERAL									
Specific Gravity	D 792		1.1	1.1	0.95	0.98	1.04	1.15	1.14
Density	D 1622	lb/ft³	68.7	68.7	59.3	61.2	64.9	71.8	71.2
Thickness		in	0.118	0.118	0.150	0.125	0.125	0.125	0.125
Shore Hardness	D 2240	A or D	82 A	90 A		50 D	58 D	60 D	60 D
Mold Shrinkage	(Bayer)	%	1.25	1.42	0.6	1.3	1.3	0.6	0.7
Water Immersion, Length Increase	(Bayer)	in/in	0.015	0.014		0.008	0.006		0.002
Water Absorption:	(Bayer)								
24 Hours		%	3.3	3.3					
240 Hours		%	5.0	5.0		2.8	2.8		2.6
MECHANICAL									
Tensile Strength, Ultimate	D 638/D 412	lb/in²	1,900	2,200	2,300	3,000	3,500	3,300	2,800
Elongation at Break	D 638/D 412	%	360	300	90	260	250	140	200
Flexural Modulus:	D 790								
149°F		lb/in²	4,000	7,900			38,000	111,000	60,000
73°F		lb/in²	5,000	10,000	71,000	25,000	52,000	125,000	100,000
-22°F		lb/in²	14,500	23,600			115,000	250,000	160,000
Tear Strength, Die C	D 624	lbf/in	230	240	400	350	450	640	620
Impact Strength:	D 256								
Notched Izod		ft-lb/in				8	11	3	8
THERMAL									
Heat Sag:	D 3769								
6-in Overhang, 1 hr at 250°F		in			0.43	0.51	0.60		0.28
4-in Overhang, 1 hr at 250°F		in					0.36	0.16	0.27
Coefficient of Linear Thermal Expansion	D 696	in/in/°F	53 E-06	53 E-06			61 E-06	27 E-06	44 E-06

* These items are provided as general information only. They are approximate values and are not part of the product specifications.
1 10% calcium silicate and 3% glass microspheres.
2 RRIMGLOS 10013 (RRIMGLOS is a trademark of NYCO Minerals, Inc.).
3 Milled glass fiber, OCF 737, 1/16 inch.
4 Calcium silicate.

first Rimball used this 12-17-97

Note 1
All directional properties are listed parallel to flow.

Note 2
IMR: Internal Mold Release.
RIM: Reaction Injection Molding.
XGT: Extended Gel Time.

CW 0308776

Bayflex®

Polyurethane Elastomeric RIM (continued)

110-80		180		XGT-16	XGT-50	XGT-80		XGT-100		XGT-140
Unfilled	15% Glass[3]	15% Mineral[4]	20% Mineral[4]	Unfilled	Unfilled	Unfilled	15% Glass[3]	Unfilled	15% Glass[3]	Unfilled
1.04	1.14	1.18	1.23	1.04	1.04	1.04	1.15	1.04	1.15	1.04
64.9	71.2	73.7	76.8	64.9	64.9	64.9	71.8	64.9	71.8	64.9
0.125	0.125	0.150	0.150	0.125	0.125	0.125	0.125	0.125	0.125	0.125
				45 D	55 D	65 D	70 D	69 D	73 D	71 D
1.3	0.7		0.55-0.65	0.85	0.85	0.85	0.6	0.85	0.6	0.85
3,500	3,200	4,100	3,900	2,400	3,500	3,700	3,800	4,000	4,100	4,200
135	75	150	130	250	200	150	75	140	50	80
51,000	100,000				18,000	33,000	78,000	45,000	95,000	50,000
80,000	150,000	183,000	195,000	16,000	50,000	83,000	170,000	100,000	210,000	140,000
200,000	275,000				105,000	180,000	280,000	220,000	400,000	260,000
470	600	580	630	450	530	630	650	670	680	700
5	3	2.8	3.2		12.5	12	5	7	4	4.5
		0.20	0.05							
0.31	0.16				0.67	0.59	0.39	0.59	0.43	0.59
61 E-06	28 E-06			78 E-06	61 E-06	61 E-06	31 E-06	61 E-06	28 E-06	61 E-06

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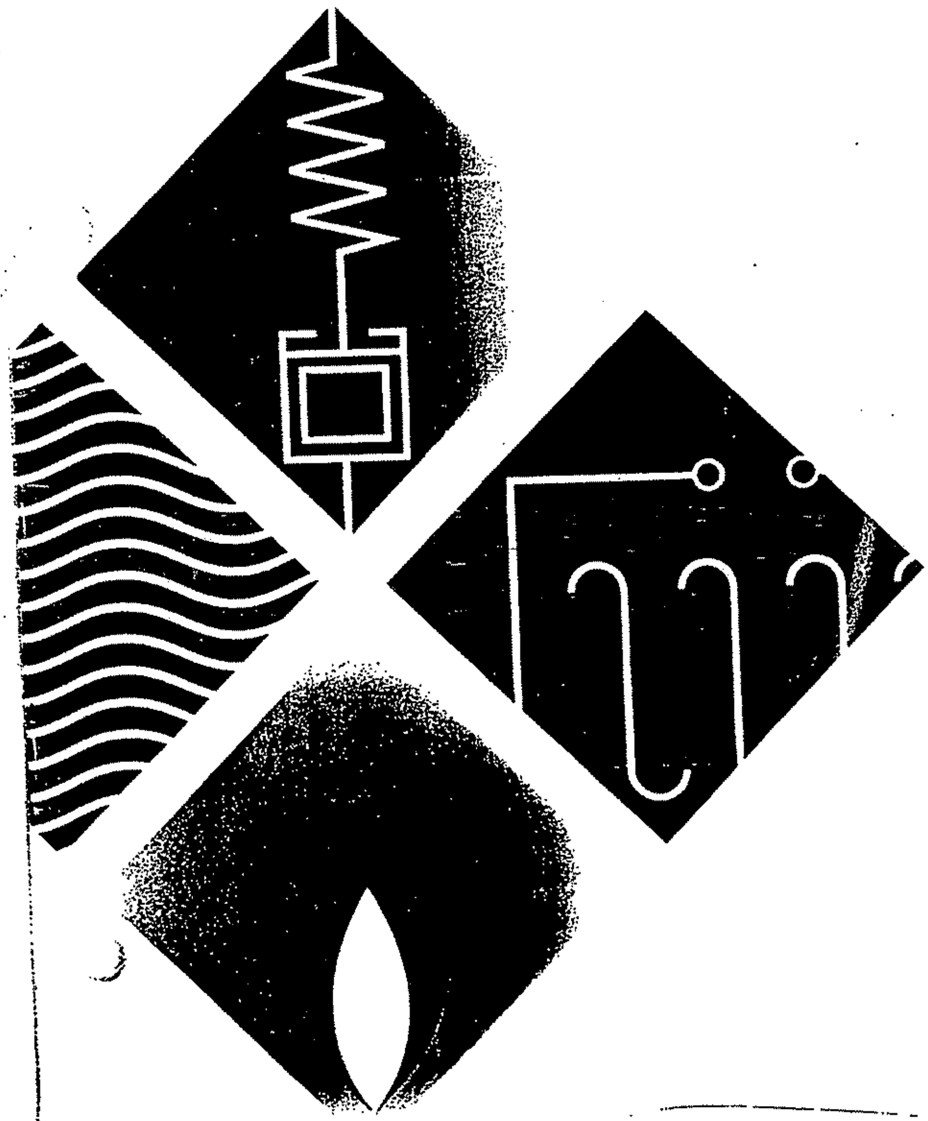
MILES

Engineering Polymers

Properties Guide



Thermoplastics

and

Thermosets

ENGINEERING THERMOPLASTICS BY MILES

The Polymers Division of Miles* supplies thermoplastic and thermoset polymers, technology, and equipment for a wide range of applications and industries.

Thermoplastics
The Plastics Department offers an extensive range of engineering thermoplastic resins and specialty plastics. In addition to the products listed in this brochure, polycarbonate films and thermoplastic urethane films are also available.

For information, please call 1-800-622-6004.

Products	Features
MAKROLON Polycarbonate Pages 6-9	Glass-like transparency Outstanding impact strength Good thermal resistance Excellent dimensional stability Good electrical properties
APEC High-Heat Polycarbonate Page 9	Glass-like transparency High deflection temperature under load High impact strength Excellent dimensional stability
BAYBLEND Polycarbonate/ABS Blend Pages 10-11	Good impact resistance even at low temperatures Rigidity and dimensional stability Easy processing Good color stability to indoor lighting Good thermal stability
MAKROBLEND Polycarbonate Blend Pages 12-13	Good chemical resistance Excellent impact resistance even at low temperatures Good abrasion resistance Good processibility and thermal stability Rigidity and dimensional stability
DURETHAN** Polyamide 6 (formerly Nydur Polyamide 6) Pages 14-17	High strength, rigidity and hardness Excellent toughness and impact resistance High dynamic fatigue resistance Excellent abrasion and chemical resistance High heat resistance in reinforced grades Good electrical insulating properties
TEXIN and **DESMOPAN** Thermoplastic Polyurethane Pages 18-19	Excellent abrasion resistance Excellent resistance to fuels and oils High tensile and tear strength High elasticity and resilience Good vibration dampening Shore hardness range from 85A to 75D

* On January 1, 1992, all Mobay businesses began operating under the corporate name Miles Inc.
** Durethan polyamide was previously supplied by the corporate predecessor of Miles Inc. under the trademark Nydur.
a Makroblend DP4-1370 resin (natural color) can be used for food-contact applications except for those in which the temperature exceeds 250°F and the food contains more than 50% alcohol. Since color possibilities for food-contact applications are limited, please contact your Miles representative for information on available colors and their limitations.

ENGINEERING
THERMOPLASTICS BY MILES

Grades	Markets and Applications
General-Purpose High-Productivity Impact-Modified Glass-Reinforced Flame-Retardant Structural Foam Extrusion Medical Optical Lighting Automotive Lens	**Automotive and Transportation:** forward and rear lighting components, instrument panels, aircraft canopies **Building and Construction:** extrusion resin for monolayer and structured sheet, profiles **Business Machines:** computer and printer housings, sight windows **Consumer:** power tool housings, food storage containers, appliances, sporting goods **Electrical/Electronic:** electric meter covers, telephone components, lighting diffusers and lenses [b]**Medical:** diagnostic, cardiovascular and intravenous devices; drug delivery systems; packaging **Optical:** ophthalmic (prescription), safety and specialized lenses for the military, industrial and sports markets **Optical Memory:** audio compact discs, data storage discs **Packaging:** bottles, film
General-Purpose Flame-Retardant Medical	**Automotive and Transportation:** reflectors, lenses, and light pipes for interior and exterior lighting **Consumer:** steam iron water tanks, hair dryer components, microwave oven doors, gas range controls and ignition switches **Electrical/Electronic:** fuses, switch housings; lighting reflectors, diffusers and lenses **Industrial/Mechanical:** emergency equipment, face shields, indicator lenses [b]**Medical:** packaging, surgical lighting, autoclavable devices
General-Purpose High-Productivity Glass-Reinforced Flame-Retardant Flame-Retardant, Antimony/Bromine-Free Structural Foam	**Automotive:** interior and exterior parts, wheel covers, instrument panels **Business Machines:** computer, monitor and printer housings; general office equipment **Consumer:** household appliances, food service trays, smoke detectors, lawn and garden equipment **Electrical/Electronic:** modular plugs, wiring devices
Impact-Modified Glass-Reinforced Flame-Retardant [a]FDA-Compliant	**Automotive:** body panels, bumpers, interior switches **Consumer:** appliances, lawn and garden equipment, sporting goods, telecommunications equipment **Electrical/Electronic:** connectors, electrical housings, interrupters, switch housings **Industrial/Mechanical:** meter housings, pump housings, agricultural equipment
Unreinforced Impact-Modified Glass-Reinforced Mineral-Reinforced Mineral/Glass-Reinforced Reduced-Moisture and Impact-Modified versions of Glass-Reinforced and Mineral-Reinforced grades are available. Film grades available (not listed in table).	**Automotive:** interior and exterior parts, door handles, mirrors, wheel covers **Consumer:** furniture, lawn and garden equipment, power tool housings, sporting goods **Electrical/Electronic:** wiring devices, switch housings, fuse holders **Industrial/Mechanical:** pumps, fans, pneumatic tools, housings **Packaging:** film for packaging of food, chemicals, medical and industrial goods
Polyester Polyether Polyurethane/Polycarbonate Blends Medical Extrusion	**Automotive:** cams, gears, mechanical parts, exterior applications, side body molding **Building and Construction:** extrusion resins for film and sheet **Consumer:** golf balls, ski goggle frames, shoe components, ski boots **Industrial/Mechanical:** mine screens, animal identification tags, hydraulic seals, hoses, caster wheels, grain buckets [b]**Medical:** diagnostic devices, tubing and catheters, connectors

[b] It is the responsibility of the medical device manufacturer to determine the suitability of all component parts and raw materials, including Apec, Makrolon, and Texin resins, used in its final product in order to ensure safety and compliance with FDA requirements. This determination must include, as applicable, testing for suitability as an implant device and suitability as to contact with and/or storage of liquids including, without limitation, medication, blood, or other bodily fluids. Under no circumstances, however, may Apec, Makrolon or Texin resin be used in any bodily implant applications for greater than 29 days. For aromatic grades of Texin resins, longer-term uses are not permissible because possible hydrolysis of solid polyurethane may produce aromatic amines, such as MDA. The sterilization method and the number of sterilization cycles a part made from these resins can withstand will vary depending upon the type of resin, part design, and processing parameters. Therefore, the manufacturer must evaluate each application to determine the sterilization method and the number of sterilization cycles appropriate for exact end-use requirements. Parts molded or extruded from Texin resins are sterilizable using ethylene oxide, radiation, or dry heat. Steam autoclaving and boiling water methods must not be used with aromatic grades of Texin resin because possible hydrolysis may produce aromatic amines, such as MDA.

ENGINEERING
THERMOSETS BY MILES

Thermosets

The Polymers Division produces polyurethane raw materials and systems for the automotive, appliance, construction and furniture industries, as well as many other markets, such as consumer, industrial/mechanical, medical, and specialty transportation. In addition to the specialty systems listed in this brochure, the Polyurethanes Department offers integral skin foams; elastomeric, microcellular soling systems for the production of shoe soles; semirigid foams, and high-resilience foams. Moreover, a full range of raw materials and additives includes diphenylmethylene diisocyanate (MDI), toluene diisocyanate (TDI), and polyols. A complete line of equipment for polyurethane processing is produced by the division's Hennecke Machinery Group.

For information, please call 1-800-622-6004.

Products	Features
BAYFLEX Elastomeric Polyurethane RIM Systems Page 20	Two-component, MDI-based liquid systems Large-part moldability Wide range of flexural moduli Superior impact strength Light weight Excellent surface quality In-mold coating
BAYDUR STR Composite Polyurethane RIM Systems Page 21	Two-component, MDI-based liquid systems Exceptional impact strength and stiffness Used for large structural parts
BAYDUR Structural Foam Polyurethane RIM Systems Page 21	Two-component, MDI-based liquid systems Large-part moldability Stiffness High-gloss finish and excellent surface quality In-mold coating Used for thick and thin wall thicknesses
PRISM Solid Polyurethane RIM Systems Page 21	Two-component, MDI-based liquid systems Stiffness High strength-to-weight ratio Good chemical resistance Good heat deflection temperature Excellent surface quality
BAYTEC RE Elastomeric and Structural Polyurethane Spray Systems Page 22	Two-component, MDI-based liquid spray systems Low-viscosity, solvent-free liquids (negligible VOCs) Used for structural parts [illegible] [illegible] membranes/liners Good adhesion to substrates Fast reaction and cure times [illegible] laminates
BAYTEC RTM Polyurethane Systems for Resin Transfer Molding Page 22	Two-component, MDI-based liquid systems Low-viscosity, solvent-free liquids (negligible VOCs) High flexural modulus without postcure Outstanding impact resistance at high and low temperatures, with and without glass Fast reaction times and early, high green strength
BAYTEC Polyurethane Prepolymers for Cast Elastomers Page 23	MDI-based prepolymers Dynamic load-bearing ability Outstanding resilience Superior tear resistance Corrosion and abrasion resistance Flexible over a wide temperature range

ENGINEERING
THERMOSETS BY MILES

Grades	Markets and Applications
Unfilled Glass-Filled	**Agricultural/Construction Equipment:** Hay conditioning rollers, tractor body panels and door frames **Automotive:** Fascias, body panels, aftermarket restyling packages **Specialty Transportation:** Heavy-duty truck bumpers, snowmobile hoods, work vehicles
General-Purpose, Foamed General-Purpose, Solid	**Automotive:** Bumper beams, inner door panels, interior trim **Construction:** Home entry door skins **Consumer:** Water sports equipment
General-Purpose Flame-Retardant	**Agricultural/Construction Equipment:** Tractor cab roofs and consoles **Automotive:** Aftermarket spoilers **Construction:** Window and door frames **Consumer:** Speaker housings, snow and water skis **Electrical/Electronic:** Instrumentation and equipment housings, Nema 1 and 12 enclosures, telecommunications equipment **Medical:** Analytical and diagnostic equipment housings
General-Purpose Flame-Retardant	**Electrical/Electronic:** Telecommunications equipment, instrumentation and equipment housings **Medical:** Analytical and diagnostic equipment housings, laboratory instrumentation
Elastomeric Structural [illegible]	**Automotive:** Aftermarket restyling packages **Consumer:** On-deck marine accessories, spas and bathtubs **Industrial/Mechanical:** Industrial liners, dump truck liners, containers, agricultural parts **Miscellaneous:** Protection for wood, metal and concrete
General-Purpose	**Automotive:** Aftermarket restyling packages **Consumer:** Marine accessories, radar dishes **Industrial/Mechanical:** Pump housings, valve bodies, fan blades **Specialty Transportation:** Components for heavy trucks, recreational vehicles, tractors, and construction vehicles
Polyester Poly(tetramethylene ether) glycol Poly(propylene ether) glycol	**Industrial/Mechanical:** Tires and wheels, rolls, hydrocyclones, pipeline pigs, seals and gaskets, gears and sprockets, die-cut pads and chopper cots, belts, liners, classifier screens, conveyor belt scrapers, shock absorbers

MAKROLON POLYCARBONATE

Makrolon Polycarbonate

THERMOPLASTICS

			General-Purpose		High-Productivity		Extrusion
			3200 3100	2800 2600	FCR-2405 FCR-2407 FCR-2458	2205	HMS-3118
GENERAL							
Specific Gravity	D 792		1.20	1.20	1.20	1.20	1.20
Density	D 792	lb/in³	0.043	0.043	0.043	0.043	0.043
Specific Volume	D 792	lb/in³ in³/lb	23.1	23.1	23.1	23.1	23.1
Mold Shrinkage	D 955	in/in	0.006-0.008	0.006-0.008	0.005-0.007	0.005-0.007	0.006-0.008
Water Absorption (Immersion at 73°F):	D 570						
24 Hours		%	0.15	0.15	0.15	0.15	0.15
Equilibrium		%	0.35	0.35	0.35	0.35	0.35
Melt Flow Rate** at 300°C/1.2-kg Load	D 1238	g/10 min g/10 min	4.5 (3200) 6.5 (3100)	10 (2800) 12 (2600)	20.5	33	<3
OPTICAL							
Transmittance at 0.125-in Thickness	D 1003*	%	88	88	88	88	87
Haze at 0.125-in Thickness	D 1003	%	1.0	1.0	1.0	1.0	1.0
Refractive Index	D 542		1.586	1.586	1.584	1.584	1.586
MECHANICAL							
Tensile Stress at Yield	D 638	lb/in²	9,100	9,100	9,100	9,100	9,100
Tensile Stress at Break	D 638	lb/in²	10,500	10,500	10,000	8,700	10,000
Tensile Elongation at Yield	D 638	%	6	6	6	6	6
Tensile Elongation at Break	D 638	%	125	120	120	110	110
Tensile Modulus	D 638	lb/in²x10³	350	350	350	330	350
Flexural Stress at 5% Strain	D 790	lb/in²	12,500	12,500	12,000	12,000	12,400
Flexural Modulus	D 790	lb/in²x10³	330	330	330	340	340
Impact Strength, Notched Izod:							
0.125-in Thickness, 73°F	D 256	ft-lb/in	18	17	14	12	17
0.250-in Thickness, 73°F	D 256	ft-lb/in	2.4	2.2	2		2.2
Rockwell Hardness	D 785	M Scale	75	75	75	75	
		R Scale	118	118	118	118	124
Falling Dart Impact (10-lb Wt., 1-in Dia. Dart)	(Miles)	ft-lb					
THERMAL							
Deflection Temperature, Unannealed:	D 648						
264-psi Load		°F	270	268	259	252	266
66-psi Load		°F	288	280	273	273	280
Coefficient of Linear Thermal Expansion	D 696	in/in/°F	3.9 E-05	3.9 E-05	3.9 E-05	3.9 E-05	3.9 E-05
Thermal Conductivity	C 177	Btu-in/(h-ft²-°F)	1.39	1.39	1.39	1.39	1.39
Specific Heat	D 2766	Btu/(lb-°F)	0.28	0.28	0.28	0.28	0.28
Relative Temperature Index[a]	(UL746B)						
Electrical		°C	125	125	125		75
Mechanical with Impact		°C	115	115	115		75
Mechanical without Impact		°C	125	125	125		75
Vicat Softening Temperature: Rate A	D 1525	°F	315	315	304	289	307
FLAMMABILITY†							
Oxygen Index	D 2863	%	26	26	26	26	26
UL94 Flame Class:	(UL94)						
0.062-in (1.57-mm) Thickness		Rating	HB	V-2	V-2		HB[b]
0.125-in (3.18-mm) Thickness		Rating	HB	V-2	V-2		
0.144-in (3.66-mm) Thickness		Rating					
0.175-in (4.45-mm) Thickness		Rating					
0.250-in (6.35-mm) Thickness		Rating	V-2	V-0	V-2		
ELECTRICAL							
Volume Resistivity (Tinfoil Electrodes)	D 257	ohm-cm	1.0 E+16	1.0 E+16	1.0 E+16	1.0 E+16	1.0 E+16
Surface Resistivity	D 257	ohm	1.0 E+15	1.0 E+15	1.0 E+15	1.0 E+15	1.0 E+15
Dielectric Strength (Short Time under Oil at 73°F, 0.062-in Thickness)	D 149	V/mil	760	760	760	760	760
Dielectric Constant (Tinfoil Electrodes): 60 Hz	D 150		3.0	3.0	3.0	3.0	3.0
1 MHz			2.9	2.9	2.9	2.9	2.9
Dissipation Factor (Tinfoil Electrodes): 60 Hz	D 150		0.0009	0.0009	0.0008	0.0008	0.0009
1 MHz			0.01	0.01	0.01	0.01	0.01
Arc Resistance: Stainless Steel Electrodes	D 495	s	11	11	11		11
Tungsten Electrodes		s	120	120	120		120

* These items are provided as general information only. They are approximate values and are not part of the product specification.
** For information on using melt flow as a quality control procedure, see Miles processing literature.
† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.

MAKROLON POLYCARBONATE

Makrolon Polycarbonate (continued)

Flame-Retardant			Impact-Modified		Glass-Reinforced		Structural Foam		
High-Productivity						Flame-Retardant	(Properties at indicated foam density)		
FCR-6255	6355 6455	6485	T-7435	T-7855	8325 20% Glass	9415 10% Glass	SF-600 0.250 in	SF-800 0.250 in	SF-810 0.250 in
1.20 0.043 23.1 0.005-0.007 0.15 0.35 20.5	1.20 0.043 23.1 0.006-0.008 0.15 0.35 16 (6355) 12 (6455)	1.20 0.043 23.1 0.006-0.008 0.15 0.35 12	1.20 0.043 23.1 0.005-0.007 0.15 0.35 17.5	1.19 0.043 23.3 0.006-0.008 0.15 0.35 12	1.35 0.049 20.4 0.003-0.004 0.12 0.29 5	1.27 0.046 21.8 0.003-0.005 0.13 0.32 7	(Solid) 1.23 (Foam) 0.90 (Solid) 0.044 (Foam) 0.033 0.005-0.007 0.15 0.30 7	(Solid) 1.23 (Foam) 0.90 (Solid) 0.044 (Foam) 0.033 0.005-0.007 0.15 0.30 5.5	(Solid) 1.27 (Foam) 0.95 (Solid) 0.046 (Foam) 0.034 0.004-0.006 0.15 0.30 6.5
Opaque Only	87 (6455) 1.2 (6455) 1.586	Opaque Only	Opaque Only	Opaque Only	Opaque Only	Opaque Only	Opaque Only	Opaque Only	Opaque Only
9,100 10,000 6 110 350 12,100 330 13 2 75 118	9,100 10,000 6 110 350 13,200 330 16 2 70	9,100 10,500 6 110 350 13,200 330 12[d] 2 70	7,900 8,100 6 110 300 12,000 305 13.9 10 53 122	9,100 9,000 6 110 340 12,500 320 15 12	15,000 5 19,500 800 3 2.4 81 6.0	11,600 10,000 5 10 580 15,000 500 2 75	5,600 5 300 10,800 330 30	6,100 5 300 11,000 340 35	6,300 4 310 12,000 405 22
259 273 3.9 E-05 1.39 0.28 125 115 125 304	264 277 3.9 E-05 1.39 0.28 125 115 125 315	262 277 3.9 E-05 1.39 0.28 125 110 125 315	250 266 3.7 E-05 293	259 273 3.9 E-05 290	290 293 1.7 E-05 1.53 0.27 75 75 75	284 295 2.1 E-05 1.46 0.27 125 115 125	261 280 2.8 E-05 1.05 0.28 75 75 75	261 280 2.8 E-05 1.05 0.28 75 75 75	273 292 1.9 E-05 0.92 0.29 75 75 75
35 V-2 V-0 V-0	35 V-2 V-0 V-0	35 V-0 V-0/5VA V-0		26	32 V-0[c]	35 V-0 V-0/5VA[c] V-0/5VA	V-0/5VA	V-0/5VA	V-0 V-0/5VA V-0/5VA
1.0 E+16 1.0 E+15 760 3.0 2.9 0.0009 0.01 115	1.0 E+16 1.0 E+15 760 3.0 2.9 0.0009 0.01 115	1.0 E+16 1.0 E+15 760 3.0 3.0 0.0009 0.01 115		>400 3.0 3.1 0.0018 0.011 100	1.0 E+16 1.0 E+14 760 3.2 3.2 0.0009 0.01 30-80	1.0 E+16 1.0 E+14 760 3.2 3.0 0.0008 0.008 115	1.0 E+16 1.0 E+15 >209 2.6 2.6 0.0031 0.0022	1.0 E+16 1.0 E+15 >400 3.0 2.9 0.0031 0.0022	1.0 E+16 1.0 E+15 >400 3.1 3.0 0.0031 0.0022

[a] The thickness at which relative temperature index values are reported in this section corresponds to the thinnest specimen thickness for which a UL94 flame class rating appears in the flammability section.
[b] Natural color.
[c] Natural and black colors.
[d] Value depends on pigment package.

CW 0308785

MAKROLON POLYCARBONATE

Makrolon Polycarbonate (continued)

THERMOPLASTICS Typical Physical Properties* for Natural Resins	ASTM Test Method (Miles)	U.S. Conventional Units	Specialty: Lighting LTG-2623	LTG-3123	Specialty: Optical LQ-2847 1006 Tint	LQ-3147 1006 Tint	LQ-3187
GENERAL							
Specific Gravity	D 792		1.20	1.20	1.20	1.20	1.20
Density	D 792	lb/in³	0.043	0.043	0.043	0.043	0.043
Specific Volume	D 792	in³/lb	23.1	23.1	23.1	23.1	23.1
Mold Shrinkage	D 955	in/in	0.005-0.007	0.006-0.008	0.006-0.008	0.006-0.008	0.006-0.008
Water Absorption (Immersion at 73°F):	D 570						
24 Hours		%	0.15	0.15	0.15	0.15	0.15
Equilibrium		%	0.35	0.35	0.35	0.35	0.35
Melt Flow Rate:** 300°C/1.2-kg Load	D 1238	g/10 min	11	6.5	12	6.5	6.5
320°C/1.2-kg Load		g/10 min					
OPTICAL							
Transmittance at 0.125-in Thickness	D 1003	%	87^c	87^c	89	89	87
Haze at 0.125-in Thickness	D 1003	%	1.0^c	1.0^c	1.0	1.0	1.0
Refractive Index	D 542*		1.586^c	1.586^c	1.586	1.586	
UV Cut-Off Wavelength at 0.125-in Thickness	(Miles)	nm			380	380	400
MECHANICAL							
Tensile Stress at Yield	D 638	lb/in²	9,100	9,100	9,100	9,100	9,100
Tensile Stress at Break	D 638	lb/in²	10,500	10,500	10,500	10,500	10,500
Tensile Elongation at Yield	D 638	%	6	6	6	6	6
Tensile Elongation at Break	D 638	%	120	125	120	125	125
Tensile Modulus	D 638	lb/in²x10³	350	350	350	350	350
Flexural Stress at 5% Strain	D 790	lb/in²	12,500	12,500	12,500	12,500	12,500
Flexural Modulus	D 790	lb/in²x10³	330	330	330	330	330
Impact Strength:							
Notched Izod, 0.125-in Thickness, 73°F	D 256	ft-lb/in	16	18	16	16	16
Notched Izod, 0.250-in Thickness, 73°F	D 256	ft-lb/in	2.2	2.4	2.2	2.2	2.1
Unnotched, 0.125-in Thickness, 73°F	D 4812	ft-lb/in					
Unnotched, 0.125-in Thickness, –40°F	D 4812	ft-lb/in					
Rockwell Hardness	D 785	M Scale					
		R Scale	118	118	120	120	120
Instrumented Impact, Total Energy:	D 3763						
0.125-in Thickness, 15 mph, 3-in Clamp							
73°F		ft-lb					
–20°F		ft-lb					
THERMAL							
Deflection Temperature, Unannealed:	D 648						
264-psi Load		°F	266	270	264	266	266
66-psi Load		°F	275	287	277	284	284
Coefficient of Linear Thermal Expansion	D 696	in/in/°F	3.9 E-05	3.9 E-05	3.9 E-05	3.9 E-05	3.9 E-05
Thermal Conductivity	C 177	Btu·in/(h·ft²·°F)	1.39	1.39	1.39	1.39	1.39
Specific Heat	D 2766	Btu/(lb·°F)	0.28	0.28	0.28	0.28	0.28
Relative Temperature Index at 0.062-in Thickness:	(UL746B)						
Electrical		°C	125	125	125	125	
Mechanical with Impact		°C	115	115	115	115	
Mechanical without Impact		°C	125	125	125	125	
Vicat Softening Temperature: Rate A	D 1525	°F	315	315	315	315	315
Rate B		°F					
FLAMMABILITY†							
Oxygen Index	D 2863	%	26	26	26		26
UL94 Flame Class:	(UL94)						
0.062-in (1.57-mm) Thickness		Rating	V-2	HB	V-2	HB	
0.125-in (3.18-mm) Thickness		Rating	V-2	HB	V-2	HB	
0.250-in (6.35-mm) Thickness		Rating	V-0	V-2	V-0	V-2	
ELECTRICAL							
Volume Resistivity (Tinfoil Electrodes)	D 257	ohm·cm	1.0 E + 16	1.0 E + 16	1.0 E + 16	1.0 E + 16	1.0 E + 16
Surface Resistivity	D 257	ohm	1.0 E + 15	1.0 E + 15	1.0 E + 15	1.0 E + 15	1.0 E + 15
Dielectric Strength (Short Time under Oil, 73°F)*	D 149	V/mil	>400	>400	>400	>400	>400
Dielectric Constant (Tinfoil Electrodes): 60 Hz	D 150		3.0	3.0	3.0	3.0	3.0
1 MHz			2.9	2.9	2.9	2.9	2.9
Dissipation Factor (Tinfoil Electrodes): 60 Hz	D 150		0.0009	0.0009	0.0009	0.0009	0.0009
1 MHz			0.01	0.01	0.01	0.01	0.01
Arc Resistance: Stainless Steel Electrodes	D 495	s			11	11	11
Tungsten Electrodes		s			30-90	30-90	30-90

* These items are provided as general information only. They are approximate values and are not part of the product specification.
** For information on using melt flow as a quality control procedure, see Miles processing literature.
† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.

APEC HIGH-HEAT POLYCARBONATE

Makrolon Polycarbonate (continued) | **Apec** High-Heat Polycarbonate

Specialty – Automotive Lens: AL-2247 1058 Tint	Specialty – Automotive Lens: AL-2447 1058 Tint	Specialty – Automotive Lens: AL-2647 1058 Tint	Specialty – Medical: Rx-2530 1118 Tint	General-Purpose: HT DP9-9331	General-Purpose: HT DP9-9340[b] HT DP9-9341	General-Purpose: HT DP9-9350[b] HT DP9-9351	General-Purpose: HT DP9-9361	General-Purpose: HT DP9-9371	Flame-Retardant: HT DP9-9354T	Flame-Retardant: HT DP9-9354
1.20 0.043 23.1 0.005-0.007	1.20 0.043 23.1 0.005-0.007	1.20 0.043 23.1 0.006-0.008	1.20 0.043 23.1 0.006-0.008	1.18 0.043 23.5 0.007-0.008	1.17 0.042 23.6 0.007-0.008	1.15 0.042 24.1 0.008-0.009	1.15 0.042 24.1 0.008-0.009	1.14 0.041 24.3 0.008-0.009	1.15 0.042 24.1 0.008-0.009	1.15 0.042 24.1 0.008-0.009
0.15 0.35 33	0.15 0.35 19	0.15 0.35 12	0.15 0.30 15	0.2 7-10	0.2 5-8	0.2 2-5	0.2 1-3	0.2 0.5-2	0.2 2-5	0.2 2-5
87 1.0 1.582	87 1.0 1.584	87 1.0 1.586	78 1.2 1.586	88 1.0 1.581	88 1.0 1.578	88 1.0 1.572	88 1.0 1.570	88 1.0 1.565	87 1.2	Opaque Only
8,000 8,700 100 330 12,000 330	9,100 10,000 6 120 350 12,000 330	9,100 10,500 6 120 350 12,500 330	9,100 10,500 6 120 350 12,500 330	9,300 9,500 6 90 325 12,500 330	9,600 9,300 6 80 325 12,500 330	9,600 9,000 6 80 325 12,500 330	9,800 8,600 6 70 325 12,500 330	10,000 8,300 6 70 325 12,500 330	9,600 9,000 6 50 325 12,500 330	9,600 9,000 6 30 325 12,500 330
10	14 2	15 2	15.6 1.4	12	6	2	1.8	1.5	1.8	1.8
No Break No Break	 75 118	 75 118	 87	No Break No Break 75 125	No Break No Break 83 127	No Break No Break 84 127	No Break No Break 89 127	No Break No Break 91 127	No Break No Break	No Break No Break
				50 48		49 47		46 39	43 34	43 34
254 270	259 273 3.9 E-05 1.39 0.28	264 275 3.9 E-05 1.39 0.28	259 273 3.9 E-05	284 306 4.2 E-05	302 324 4.2 E-05	324 345 4.2 E-05 1.44	336 365 4.2 E-05	354 383 4.2 E-05	324 345 4.2 E-05 1.44	324 345 4.2 E-05 1.44
	125 115 125	125 115 125		140 130 140	75 75 75	150 130 150	75 75 75	75 75 75	75 75 75	75 75 75
291	304	315		320	341	365	383	401	365	365
	26	26		24	24	24	24	24	35	35
	V-2 V-2 V-2	V-2 V-2 V-0		HB HB	HB HB	HB HB	HB HB	HB HB	V-2 V-0	V-0 V-0/5VA
	1.0 E + 16 1.0 E + 15 760 3.0 2.9 0.0008 0.01 11 30-90	1.0 E + 16 1.0 E + 15 760 3.0 2.9 0.0009 0.01	1.0 E + 16 1.0 E + 15 >400 3.0 3.0 0.001 0.01 11 30-90	>1.0 E + 16 >1.0 E + 16 >400 3.0 3.0 0.001 0.01	>1.0 E + 16 >1.0 E + 16 >400 2.9 2.9 0.001 0.01	>1.0 E + 16 >1.0 E + 16 >400 2.9 2.9 0.001 0.01	>1.0 E + 16 >1.0 E + 16 >400 2.9 2.9 0.001 0.01	>1.0 E + 16 >1.0 E + 16 >400 2.8 2.8 0.001 0.01	1.0 E + 15 1.0 E + 14 >400 2.8 2.9 0.005 0.01	1.0 E + 15 1.0 E + 14 >400 2.8 2.9 0.003 0.01

[a] Dielectric strength properties are reported at 0.062-inch thickness for grades of Makrolon polycarbonate and at 0.125-inch thickness for grades of Apec high-heat polycarbonate.
[b] HT DP9-9340 and HT DP9-9350 are medical grades of Apec resin.
[c] This value does not apply to color 3331 white.

BAYBLEND POLYCARBONATE/ABS BLEND

Bayblend PC/ABS Blend

THERMOPLASTICS

			General-Purpose			High-Productivity	
			T 45 MN	T 65 MN	6 85 MN	T 44	T 64
GENERAL							
Specific Gravity	D 792		1.10	1.13	1.15	1.10	1.13
Density	D 792	lb/in³	0.040	0.041	0.041	0.040	0.041
		lb/in³					
Specific Volume	D 792	in³/lb	25.2	24.1	24.3	25.2	24.1
Mold Shrinkage	D 955	in/in	0.005-0.007	0.005-0.007	0.005-0.007	0.005-0.007	0.005-0.007
Water Absorption (Immersion at 73°F):	D 570						
24 Hours		%	0.2	0.2	0.2	0.2	0.2
Equilibrium		%	0.7	0.6	0.6	0.7	0.6
Melt Flow Rate** at 250°C/5-kg Load	D 1238	g/10 min	5-11	5-11	5-11	10-16	10-16
Spiral Flow Length at 0.100-in Thickness:	(Miles)*						
490°F Melt Temperature		in	22.5	19.0	16.5	23.5	22.3
525°F Melt Temperature		in	26.0	23.0	20.5	27.0	26.0
MECHANICAL							
Tensile Stress at Yield	D 638	lb/in²	6,500	7,200	8,000	6,500	7,200
Tensile Stress at Break	D 638	lb/in²	5,800	6,500	7,200	5,800	6,500
Tensile Elongation at Yield	D 638	%	4	4	5	3	4
Tensile Elongation at Break	D 638	%	70	80	85	60	70
Tensile Modulus	D 638	lb/in²x10³					
Flexural Stress at 5% Strain	D 790	lb/in²	10,100	10,900	11,600	8,700	9,400
Flexural Modulus	D 790	lb/in²x10³	290	305	320	290	305
Impact Strength, Notched Izod:	D 256						
0.125-in Thickness, 73°F		ft-lb/in	9.0	10.0	11.0	8.0	9.0
0.125-in Thickness, -40°F		ft-lb/in	5.0	6.0	7.0	4.5	5.0
Rockwell Hardness	D 785	R Scale	114	118	119	95	118
Instrumented Impact, Total Energy:	D 3763						
0.125-in Thickness, 15 mph, 3-in Clamp 73°F		ft-lb	30	33	33		33
-22°F		ft-lb	28	30	33		29
0.180-in Thickness, 2.5 mph, 3-in Clamp, 73°F		ft-lb					
0.250-in Thickness, 2.5 mph, 3-in Clamp, 73°F		ft-lb					
THERMAL							
Deflection Temperature, Unannealed:	D 648						
264-psi Load		°F	210	220	230	210	210
66-psi Load		°F	220	255	265	220	248
Coefficient of Linear Thermal Expansion	D 696	in/in/°F	4.6 E-05	4.3 E-05	4.0 E-05	4.6 E-05	4.3 E-05
Relative Temperature Index at 0.062-in Thickness:	(UL746B)						
Electrical		°C	60	60	60	60	60
Mechanical with Impact		°C	60	60	60	60	60
Mechanical without Impact		°C	60	60	60	60	60
Vicat Softening Temperature: Rate B/120	(ISO 306)	°F	230	250	270	230	250
FLAMMABILITY†							
Oxygen Index	D 2863	%	21	23	24	21	23
UL94 Flame Class:	(UL94)						
0.062-in (1.57-mm) Thickness		Rating	HB	HB	HB	HB	HB
0.089-in (2.29-mm) Thickness		Rating	HB	HB	HB	HB	HB
0.100-in (2.54-mm) Thickness		Rating	HB	HB	HB	HB	HB
0.125-in (3.18-mm) Thickness		Rating	HB	HB	HB	HB	HB
ELECTRICAL							
Volume Resistivity (Tinfoil Electrodes)	D 257	ohm-cm	>1.0 E + 16	>1.0 E + 16	>1.0 E + 16	>1.0 E + 16	>1.0 E + 16
Surface Resistivity	D 257	ohm	>1.0 E + 14	>1.0 E + 14	>1.0 E + 14	>1.0 E + 14	>1.0 E + 14
Dielectric Strength (Short Time under Oil at 73°F, 0.062-in Thickness)	D 149	V/mil	600	600	600	600	600
Dielectric Constant (Tinfoil Electrodes): 60 Hz	D 150						
1 MHz							
Dissipation Factor (Tinfoil Electrodes): 60 Hz	D 150		0.004	0.004	0.004	0.004	0.004
1 MHz			0.007	0.007	0.008	0.007	0.007

* These items are provided as general information only. They are approximate values and are not part of the product specification.
** For information on using melt flow as a quality control procedure, see Miles processing literature.
† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.

BAYBLEND POLYCARBONATE/ABS BLEND

Bayblend PC/ABS Blend (continued)

General-Purpose	Flame-Retardant					Glass-Reinforced		Structural Foam (Properties at indicated foam density)	Blow Molding/ Extrusion
High-Productivity				Antimony/Bromine-Free					
T 84	FR 1439	FR 1440	FR 1441	FR 90	FR 110	T 88-2N 10% Glass	T 88-4N 20% Glass	SF 1443 0.250 In	DP2-1500
1.15	1.17	1.18	1.18	1.17	1.19	1.20	1.25	(Solid) 1.18 (Foam) 0.90	1.21
0.041	0.042	0.043	0.043	0.042	0.043	0.043	0.045	(Solid) 0.043 (Foam) 0.033	0.043
24.3	23.7	23.5	23.5	24.8	23.2	23.1	22.2		
0.005-0.007	0.0043-0.0055	0.0045-0.0056	0.0048-0.0058	0.003-0.005	0.004-0.006	0.003-0.004	0.002-0.003	0.005-0.007	
0.2	0.15	0.15	0.15	0.15		0.2	0.2	0.2	
0.6						0.6	0.6	0.6	
10-16	24	19	16	35	35				3-10
19.0	27.0	22.5	18.0	28.0	22.5				10
22.8	32[a]	27.0	22.0	32[a]					
8,000	7,700	8,000	8,700	8,700	8,700	9,400	10,900	6,100	7,700
6,500	5,800	6,500	7,300	6,500	8,100	8,700	10,900		7,600
4	3.5	4	4	4	4	3	2	3.4	3.8
75	50	60	60	70	90	5	2		90
	380	390	390	400	380				
10,200	12,600	13,000	13,900	14,500	13,800	16,000	18,900	11,600	12,600
320	360	380	380	400	390	580	870	380	329
10.0	6.0	7.5	9.5	5.5	14	1.5	1.4		13
6.0									
119	115	119	121	121	122				
33	34	35	36	42	38			15	38
33								22	33
226	180	195	210	185	203	240	240	171	221
262	195	210	230		212	257	266	201	
4.0 E-05	3.9 E-05	3.9 E-05	3.9 E-05	3.9 E-05		2.3 E-05	1.8 E-05		
60	90	95	95	85	95	60	60	60[d]	60
60	70	80	85	75	85	60	60	60[d]	60
60	90	95	95	80	85	60	60	60[d]	60
270	195	210	230	200	226	270	275		264
24	28	30	30	30	30	24	24		
HB	V-0	V-0	V-0	V-0	V-0	HB	HB		V-0
HB	V-0/5VB[b]	V-0/5VB[b]	V-0/5VB	V-0/5VB	V-0/5VB	HB	HB		
HB	V-0/5VB[c]	V-0/5VB[c]	V-0/5VB	V-0/5VB	V-0/5VB	HB	HB		
HB	V-0/5VB	V-0/5VB	V-0/5VB	V-0/5VB	V-0/5VA	HB	HB	V-0	V-0/5VB[b]
>1.0 E+16	>1.0 E+16	>1.0 E+16	>1.0 E+16	>1.0 E+16		>1.0 E+16	>1.0 E+16	>1.0 E+16	
>1.0 E+14	>1.0 E+14	>1.0 E+14	>1.0 E+14	>1.0 E+14		>1.0 E+14	>1.0 E+14	>1.0 E+14	
600	760	760	760	760					
	3.0	3.0	3.0	3.0					
	2.9	2.9	2.9	2.9					
0.004	0.005	0.004	0.004	0.005		0.002	0.002		
0.008	0.007	0.007	0.007	0.007		0.009	0.009		

[a] Equipment capability exceeded.
[b] Red, black, white and yellow colors.
[c] Natural color.
[d] Thickness of relative temperature index is reported at 0.118 inch.

MAKROBLEND POLYCARBONATE BLEND

Makroblend PC Blend

THERMOPLASTICS Typical Physical Properties			Impact-Modified		Glass-Reinforced	
			UT 1018	UT 400 UT 403	UT 620 G 10% Glass	UT 640 G 20% Glass
GENERAL						
Specific Gravity	D 792		1.22	1.22	1.31	1.37
Density	D 792	lb/in³	0.044	0.044	0.047	0.050
Specific Volume	D 792	in³/lb	22.7	22.7	21.1	20.2
Mold Shrinkage	D 955	in/in	0.006-0.009	0.006-0.008	0.001-0.006	0.001-0.006
Water Absorption (Immersion at 73°F):	D 570					
24 Hours		%	0.16	0.11	0.10	0.08
Equilibrium		%	0.30	0.25	0.24	0.23
Melt Flow Rate** at 265°C/5-kg Load	D 1238	g/10 min	8-12	26-34		
Spiral Flow Length at 0.100-in Thickness:	(Miles)					
525°F Melt Temperature		in	16	28		
MECHANICAL						
Tensile Stress at Yield	D 638	lb/in²	7,000	7,900	11,000	13,000
Tensile Stress at Break	D 638	lb/in²	7,600	8,000	9,000	12,000
Tensile Elongation at Yield	D 638	%	5	5	5	5
Tensile Elongation at Break	D 638	%	165	151	5	5
Flexural Stress at 5% Strain	D 790	lb/in²	10,700	12,400	19,000	23,600
Flexural Modulus	D 790	lb/in²x10³	300	338	560	850
Impact Strength, Notched Izod:	D 256					
0.125-in Thickness, 73°F		ft-lb/in	18	15	2.6	2.4
0.125-in Thickness, −20°F		ft-lb/in	13	3	2	2
0.125-in Thickness, −40°F		ft-lb/in	8	2	2	2
0.250-in Thickness, 73°F		ft-lb/in	15	4		
Rockwell Hardness	D 785	R Scale	114	121	113	115
Instrumented Impact, Total Energy:	D 3763					
0.125-in Thickness, 15 mph, 3-in Clamp						
73°F		ft-lb	39	41		
−20°F		ft-lb	39	42		
−40°F		ft-lb	38	41		
THERMAL						
Deflection Temperature, Unannealed:	D 648					
264-psi Load		°F	190	248	237	252
66-psi Load		°F	239	273	293	354
Coefficient of Linear Thermal Expansion	D 696	in/in/°F	4.0 E-05	3.7 E-05	2.6 E-05	2.2 E-05
Relative Temperature Index at 0.062-in Thickness:	(UL746B)					
Electrical		°C	75	75	75	75
Mechanical with Impact		°C	75	75	75	75
Mechanical without Impact		°C	75	75	75	75
Vicat Softening Temperature: Rate B	D 1525	°F				
FLAMMABILITY†						
UL94 Flame Class:	(UL94)					
0.062-in (1.57-mm) Thickness		Rating	HB	HB	HB[a]	HB[a]
0.125-in (3.18-mm) Thickness		Rating	HB	HB		
0.250-in (6.35-mm) Thickness		Rating				
ELECTRICAL						
Volume Resistivity (Tinfoil Electrodes)	D 257	ohm-cm	>2.6 E+15	>7.4 E+15	>1.6 E+15	>1.4 E+15
Dielectric Strength (Short Time under Oil	D 149					
at 73°F, 0.062-in Thickness)		V/mil	713	704	>700	>700
Dielectric Constant (Tinfoil Electrodes): 1 MHz	D 150		3.06	3.1	3.2	3.3
Dissipation Factor (Tinfoil Electrodes): 1 MHz	D 150		0.014	0.009	0.0008	0.0009

* These items are provided as general information only. They are approximate values and are not part of the product specification.

** For information on using melt flow as a quality control procedure, see Miles processing literature.

† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.

[a] Black color.

MAKROBLEND POLYCARBONATE BLEND

Makroblend PC Blend (continued)

Impact-Modified		
Flame-Retardant		*FDA-Compliant*
DP4-1368	DP4-1377	DP4-1370
1.30 0.047 21.3 0.005-0.007	1.28 0.046 22 0.006-0.008	1.22 0.044 22.7 0.005-0.007
0.07 0.22 16-22	0.09 0.28 10-20	0.17 14-20
24	19	20
6,900 7,400 5 130 13,800 380	8,100 7,500 5 120 12,000 318	8,200 7,900 5 115 13,000 340
13 3 12 122	15 5 4 10 120	15 2 117
39 40 39	40 37 35	36 40 37
212 239 3.2 E-05	222 255 3.7 E-05	240 271 3.5 E-05
95 75 95	75 75 75	 315
V-0 V-0/5VA V-0	V-0 V-0/5VA	
5.9 E + 15 740 3.02 0.0007		

DURETHAN POLYAMIDE 6

Durethan Polyamide 6

THERMOPLASTICS			Unreinforced				Impact-Modified					
			B 30 S B 31 SK		B 40 SK		BC 30		BC 40		BC 303	
			Dry as Molded	Condi-tioned	Dry as Molded	Condi-tioned	Dry as Molded	Condi-tioned	Dry as Molded	Condi-tioned	Dry as Molded	Condi-tioned
GENERAL												
Specific Gravity	D 792		1.14		1.14		1.10		1.10		1.07	
Density	D 792	lb/in³	0.041		0.041		0.040		0.040		0.039	
Specific Volume	D 792	in³/lb	24.3		24.3		25.2		25.2		25.8	
Mold Shrinkage:	(Miles)											
Flow Direction		in/in	0.012		0.012		0.013		0.015		0.016	
Cross-Flow Direction		in/in	0.011		0.013		0.017		0.019		0.016	
Water Absorption (0.125-in Thickness):												
24-Hour Immersion	D 570	%	1.6		1.6		1.5		1.5		1.6	
Equilibrium (73°F):	(DIN 53495)											
In Air (50% RH)		%	3.0		3.0		2.7		2.7		1.9	
In Water		%	10.0		10.0		9.0		9.0		7.0	
MECHANICAL												
Tensile Stress at Break	D 638	lb/in²	7,250	8,700	8,000	8,000	10,200	8,000	10,200	5,800	6,500	6,500
Tensile Elongation at Break	D 638	%	35	>200	70	>200	50	>200	75	>200	>200	>200
Tensile Modulus	D 638	lb/in²x10³	464	159	450	145	406	174	406	174	254	109
Flexural Stress at 5% Strain	D 790	lb/in²	16,700	5,080	16,700	5,080	13,000	4,400	13,800	4,400	8,700	2,900
Flexural Strength	D 790	lb/in²										
Flexural Modulus	D 790	lb/in²x10³	392	102	392	102	319	116	334	116	232	102
Impact Strength, Notched Izod:	D 256											
0.125-in Thickness, 73°F		ft·lb/in	1.1	14.0	1.3	18.7	1.7	17.8	3.0		17.8	18.7
0.125-in Thickness, -40°F		ft·lb/in					1.5	1.5	2.1	2.1	2.8	3.7
THERMAL												
Deflection Temperature, Unannealed:	D 648											
264-psi Load		°F	140		140		149		158		140	
66-psi Load		°F	356		356		329		365		320	
FLAMMABILITY†												
UL94 Flame Class:	(UL94)											
0.016-in (0.40-mm) Thickness		Rating	V-2[a]									
0.032-in (0.81-mm) Thickness		Rating							HB		HB	
0.062-in (1.57-mm) Thickness		Rating	V-2		HB		HB[a]		HB			
ELECTRICAL												
Volume Resistivity (Tinfoil Electrodes)	D 257	ohm-cm	1.0E+15	1.0E+12	1.0E+15	1.0E+12	1.0E+14	1.0E+12	1.0E+14	1.0E+12	1.0E+15	1.0E+12
Surface Resistivity	D 257	ohm	1.0E+13	1.0E+12	1.0E+13	1.0E+12	1.0E+12	1.0E+10	1.0E+12	1.0E+10	1.0E+15	1.0E+14
Dielectric Strength:	(DIN 53481)											
0.118-in Thickness		V/mil	762	889	762	889	889	762	889	762	813	813
Dielectric Constant (Tinfoil Electrodes):	D 150											
50 Hz			3.8	20.0	3.8	16	3.7	14	3.7	14	3.5	10.0
1 MHz			3.4	4.6	3.4	4.7	3.3	5.8	3.3	5.8	3.1	4.5
Dissipation Factor (Tinfoil Electrodes):	D 150											
50 Hz			0.05	2.30	0.05	2.80	0.04	2.45	0.04	2.45	0.04	1.50
1 MHz			0.07	0.40	0.06	0.40	0.06	1.30	0.06	0.37	0.05	0.70
Arc Resistance (Tungsten Electrodes)	D 495	s										
Comparative Tracking Index	D 3638	V		600		600		600		600		600

* These items are provided as general information only. They are approximate values and are not part of the product specification.
† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.
\# Miles value pending UL recognition.
a Natural color.

Note 1
Dry as Molded: refers to a moisture content less than 0.2% by weight.
Conditioned: refers to an equilibrium moisture content in a standard laboratory atmosphere of 73°F and 50% relative humidity.

Note 2
Glass-Reinforced: refers to reinforcement with glass fibers except in the case of BG 30 X, which is reinforced with glass fibers and glass beads.

CW 0308792

Durethan Polyamide 6 (continued)

Impact-Modified		Glass-Reinforced								Glass-Reinforced, Impact-Modified							
BC 402		BKV 15 H 15% Glass		BKV 30 H 30% Glass		BKV 40 H 40% Glass		BKV 50 H 50% Glass		BKV 115 15% Glass		BKV 130 30% Glass		BKV 140 40% Glass		BKV 35..Z 35% Glass	
Dry as Molded	Condi-tioned	Dry as Molded	Condi-tioned	Dry as Molded	Condi-tioned	Dry as Molded	Condi-tioned	Dry as Molded	Condi-tioned	Dry as Molded	Condi-tioned	Dry as Molded	Condi-tioned	Dry as Molded	Condi-tioned	Dry as Molded	Condi-tioned
1.08		1.23		1.36		1.46		1.57		1.23		1.36		1.46		1.41	
0.039		0.044		0.049		0.053		0.057		0.044		0.049		0.053		0.051	
25.6		22.5		20.4		19.0		17.6		22.5		20.4		19.0		19.6	
0.016		0.003		0.003		0.003		0.003		0.003		0.003		0.003		0.003	
0.016		0.009		0.009		0.008		0.007		0.009		0.009		0.008		0.008	
1.7		1.3		1.0		0.85		0.80		1.30		1.00		0.85		0.90	
2.0		2.5		2.1		1.8		1.5		2.3		1.8		1.6		1.9	
8.0		8.5		7.0		6.0		5.0		8.5		7.0		6.0		6.5	
6,500	6,500	18,900	10,200	26,100	14,500	29,000	17,400	30,500	21,800	18,900	9,400	23,200	14,500	26,100	17,400	26,800	16,700
>200	>200	3	5.5	3	6	3	4	2	3.5	7	9	4	7	3.5	6.5	2.5	5
319	131	899	450	1,334	812	1,711	1,073	2,176	1,378	827	421	1,305	725	1,595	1,015	1,450	1,015
11,600	3,600	29,000	17,400	40,600	24,700	47,900	29,000	50,800	31,900	27,600	14,500	37,700	21,800	43,500	27,600	43,500	26,100
290	109	783	420	1,204	725	1,566	986	1,958	1,116	710	362	1,160	682	1,479	914	1,378	812
16.7		1.2	4.7	2.2	2.8	3.0	3.6	3.1	3.7	2.2	5.6	3.4	4.1	4.1	4.9	3.0	3.6
2.4	2.4	1.0	1.0	1.9	1.9	2.5	2.5	2.5	2.5	1.2	1.2	2.2	2.2	2.6	2.6	2.2	2.2
140		392		392		392		392		392		392		392		392	
320		419		419		419		419		419		419		419		419	
HB		HB		HB		HB#		HB		HB#		HB		HB#		HB#	
HB		HB		HB				HB									
1.0E+15	1.0E+13	1.0E+15	1.0E+12	1.0E+15	1.0E+12	1.0E+15	1.0E+12	1.0E+15	1.0E+12	1.0E+15	1.0E+12	1.0E+15	1.0E+12	1.0E+15	1.0E+11	1.0E+15	1.0E+12
1.0E+15	1.0E+14	1.0E+13	1.0E+12	1.0E+14	1.0E+12	1.0E+14	1.0E+12	1.0E+14	1.0E+12	1.0E+13	1.0E+12	1.0E+14	1.0E+12	1.0E+14	1.0E+10	1.0E+14	1.0E+12
813	889	889	762	1,016	889	1,016	889	1,016	889	1,016	889	1,016	889	1,016	889	1,016	889
3.6	12.0	4.0	15	4.0	15	4.0	15.	4.0				4.0	10	4.0	10	4.0	10
3.2	5.5	4.0	5.0	4.0	5.0	4.0	5.0	4.0	5.0			4.0	5.0	4.0	5.0	4.0	5.0
0.04	2.00	0.005	0.50	0.005	0.50	0.01		0.01				0.005	0.20	0.005	0.20	0.005	0.20
0.06	1.20	0.015	0.16	0.015	0.16	0.015	0.15	0.015	0.14			0.015	0.12	0.015	0.12	0.015	0.12
					76								87		91		
	600		425		400		375		375		600		600		575		

Film grades of Durethan polyamide 6
and copolyamide are available.
For information, call 1-800-622-6004.

Durethan Polyamide 6 (continued)

THERMOPLASTICS Typical Physical Properties for Natural Resins	ASTM Test Method (other)	U.S. Conventional Units	Glass-Reinforced, Low-Warpage BG 30 X 30% Glass Fiber/Bead Dry as Molded	Glass-Reinforced, Low-Warpage BG 30 X Conditioned	Mineral-Reinforced BM 230 H 30% Mineral Dry as Molded	BM 230 H Conditioned	BM 240 H 40% Mineral Dry as Molded	BM 240 H Conditioned	Mineral-Reinforced, Impact-Modified KU1-2402/30 30% Mineral Dry as Molded	KU1-2402/30 Conditioned
GENERAL										
Specific Gravity	D 792		1.35		1.36		1.46		1.36	
Density	D 792	lb/in³	0.049		0.049		0.053		0.049	
Specific Volume	D 792	in³/lb	20.5		20.4		19.0		20.4	
Mold Shrinkage:	(Miles)									
Flow Direction		in/in	0.007		0.012		0.010		0.012	
Cross-Flow Direction		in/in	0.008		0.012		0.010		0.012	
Water Absorption (0.125-in Thickness):										
24-Hour Immersion	D 570	%	1.00		0.80		0.70			
Equilibrium (73°F):	(DIN 53495)*									
In Air (50% RH)		%	2.1		2.0		1.8			
In Water		%	7.0		6.0		6.0			
MECHANICAL										
Tensile Stress at Break	D 638	lb/in²	18,100	9,400	11,600	7,300	12,300	7,300	10,200	8,000
Tensile Elongation at Break	D 638	%	4	9	10	45	9	35	18	55
Tensile Modulus	D 638	lb/in²x10³	899	507	725	232	870	290	638	232
Flexural Strength	D 790	lb/in²	28,300	16,000	20,300	8,700	22,500	9,400	18,900	7,300
Flexural Modulus	D 790	lb/in²x10³	798	406	667	261	783	261	609	203
Impact Strength, Notched Izod:	D 256									
0.125-in Thickness, 73°F		ft·lb/in	1.1	2.6	1.3	1.7	1.2	1.5	2.1	4.3
0.125-in Thickness, -40°F		ft·lb/in	0.9	0.9	0.7	0.7	0.7	0.7	0.8	0.8
THERMAL										
Deflection Temperature, Unannealed:	D 648									
264-psi Load		°F	356		194		221		194	
66-psi Load		°F	392		374		392		374	
FLAMMABILITY†										
UL94 Flame Class:	(UL94)									
0.032-in (0.81-mm) Thickness		Rating			HB[a]		HB[a]			
0.062-in (1.57-mm) Thickness		Rating	HB		HB[a]		HB[a]		HB[a]	
ELECTRICAL										
Volume Resistivity (Tinfoil Electrodes)	D 257	ohm·cm	1.0 E + 15	1.0 E + 12	1.0 E + 15	1.0 E + 11	1.0 E + 15	1.0 E + 11	1.0 E + 14	1.0 E + 12
Surface Resistivity	D 257	ohm	1.0 E + 16	1.0 E + 13	1.0 E + 14	1.0 E + 12	1.0 E + 14	1.0 E + 12	1.0 E + 14	1.0 E + 14
Dielectric Strength:	(DIN 53481)									
0.118-in Thickness		V/mil	889	889	889	889	889	889	889	889
Dielectric Constant (Tinfoil Electrodes):	D 150									
50 Hz			4.5	10	5.0	15	5.0	15	5.0	15
1 MHz			4.0	5.0	4.0	4.0	4.0	4.0	4.0	4.5
Dissipation Factor (Tinfoil Electrodes):	D 150									
50 Hz			0.015	0.20						
1 MHz			0.02	0.06	0.015	0.07	0.015	0.07	0.025	0.075
Arc Resistance (Tungsten Electrodes)	D 495	s		110						
Comparative Tracking Index	D 3638	V		450		575		575		600

* These items are provided as general information only. They are approximate values and are not part of the product specification.
† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.
# Miles value pending UL recognition.
a Natural color.

Note 1
Dry as Molded: refers to a moisture content less than 0.2% by weight.
Conditioned: refers to an equilibrium moisture content in a standard laboratory atmosphere of 73°F and 50% relative humidity.

Note 2
Glass-Reinforced: refers to reinforcement with glass fibers except in the case of BG 30 X, which is reinforced with glass fibers and glass beads.

Durethan Polyamide 6 (continued)

Mineral/Glass-Reinforced				Reduced-Moisture											
				Glass-Reinforced		*Glass-Reinforced, Impact-Modified*								*Mineral-Reinforced*	
BM 30 X 30% Glass/Mineral		BM 40 X 40% Glass/Mineral		RM KU2-2501/30 30% Glass		BM KU2-2521/20 20% Glass		RM KU2-2521/25 25% Glass		RM KU2-2521/30 30% Glass		RM KU2-2521/35 35% Glass		RM KU2-2561/30 30% Mineral	
Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned	Dry as Molded	Conditioned
1.38		1.46		1.36		1.28		1.32		1.36		1.41		1.36	
0.050		0.053		0.049		0.046		0.048		0.049		0.051		0.049	
20.0		19.0		20.4		21.6		21.0		20.4		19.6		20.4	
0.005		0.005		0.003		0.003		0.002		0.002		0.002		0.012	
0.009		0.009		0.009		0.009		0.008		0.007		0.007		0.012	
				0.70		0.85		0.75		0.65		0.60		0.60	
2.0		1.8		1.5		1.5		1.4		1.3		1.2		1.4	
6.0		6.0		5.0		5.6		5.3		4.9		4.6		4.2	
17,400	9,400	18,900	13,100	25,400	16,000	20,300	11,600	21,800	16,000	23,900	16,700	26,100	18,900	12,300	7,980
3.5	13	3	7	3	4	4	8	4	5	3.5	5	3.5	7	5	30
972	493	1,160	798	1,450	812	1,090	725	1,232	798	1,378	870	1,595	957	798	435
27,600	14,500	29,000	17,400	42,100	26,100	31,900	19,600	34,800	21,000	37,700	22,500	42,100	24,600	22,500	10,900
899	406	942	493	1,300	783	942	522	1,058	580	1,276	725	1,450	870	725	362
1.2	1.9	1.1	1.9	2.1	2.6	2.4	3.2	2.8	3.6	3.2	3.9	3.6	3.9		
0.7	0.7	0.7	0.7	1.9	1.9	1.5	1.5	1.8	1.8	2.1	2.1	2.2	2.2		
374		392		383		374		374		374		374		179	
428		428		410		401		401		401		401		356	
HB		HB		HB·						HB		HB			
HB		HB		HB		HB#		HB#		HB		HB		HB#	
1.0 E+14	1.0 E+13			1.0 E+15	1.0 E+12					1.0 E+15	1.0 E+12			1.0 E+15	1.0 E+13
1.0 E+14	1.0 E+13			1.0 E+14	1.0 E+12					1.0 E+14	1.0 E+12			1.0 E+16	1.0 E+15
1,016	1,016			1,016	889	1,016	1,016	1,016	1,016	1,016	889	1,016	1,016	762	762
5.0	15	5.0	15	4	10					4	10			4	8
4.0	4.5			4	4					4	4			4	4
				0.004											
0.007	0.02			0.005	0.029						0.032				
					115						108				
	600		500		600		600		600		600				

Film grades of Durethan polyamide 6 and copolyamide are available. For information, call 1-800-622-6004.

TEXIN AND DESMOPAN THERMOPLASTIC POLYURETHANE

Texin Thermoplastic Polyurethane

THERMOPLASTICS Typical Physical Properties	[illegible]	[illegible]	Polyester							
			480-A	688-A	591-A	345-D	445-D	355-D	455-D	458-D
GENERAL										
Specific Gravity	D 792		1.20	1.26	1.22	1.22	1.22	1.22	1.21	1.22
Shore Hardness	D 2240	A or D	87 A	88 A	88 A	45 D	45 D	52 D	55 D	60 D
Taber Abrasion: H-18 Wheel, 1000-g Load, 1000 Cycles	D 3489	mg Loss	15	50	40	45	70	50	50	45
Bayshore Resilience	D 2632	%	45	35	35	40	45	40	40	45
Mold Shrinkage at 100-mil Thickness:	D 955									
Flow Direction		in/in	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Cross-Flow Direction		in/in	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
Processing Methods:										
• Injection Molding			•	•	•	•	•	•	•	•
• Extrusion–Hose, Tubing, Profiles			•							
–Wire & Cable			•							
–Film & Sheet			•							
• Blow Molding			•				•		•	
Paintable Formulations Available *	•									
MECHANICAL										
Tensile Strength	D 412	lb/in²	6,000	4,500	6,000	4,500	6,000	5,000	6,000	6,000
Tensile Stress at 50% Elongation	D 412	lb/in²	720	900	1,150	1,250	1,100	1,800	1,800	2,400
Tensile Stress at 100% Elongation	D 412	lb/in²	750	1,000	1,200	1,400	1,300	2,000	2,000	3,000
Tensile Stress at 300% Elongation	D 412	lb/in²	1,700	2,000	2,800	2,500	2,600	3,100	4,000	4,700
Ultimate Elongation	D 412	%	500	600	540	500	550	500	500	450
Flexural Modulus	D 790	lb/in²	4,000	5,000	5,500	8,400	10,000	15,000	20,000	37,000
Compression Set:	D 395-B									
As Molded (Postcured)**										
22 Hours at 73°F		%	16 (12)	21 (19)	16 (12)	16 (12)	18 (18)	17 (15)	20 (15)	40 (33)
22 Hours at 158°F		%	65 (35)	65 (40)	65 (35)	65 (30)	43 (35)	62 (35)	65 (35)	64 (40)
Shear Strength	D 732	lb/in²							5,585	
Tear Strength, Die C	D 624	lbf/in	500	650	750	700	700	900	900	1,000
Impact Strength, Notched Izod:	D 256									
0.125-in Thickness, 73°F		ft-lb/in					No Break			
0.125-in Thickness, -22°F		ft-lb/in					3.3			
Instrumented Impact, Total Energy: 100-mil Thickness, 5 mph, 3-in Clamp	D 3763									
73°F		ft-lb							42.6	
–22°F		ft-lb							36.9	
THERMAL										
Deflection Temperature Under Load:	D 648									
264 psi		°F							139	131
66 psi		°F								
Coefficient of Linear Thermal Expansion	D 696	in/in/°F			8.3 E-05				7.3 E-05	
Low-Temperature Brittle Point	D 746	°F	<-90	<-40	<-90	<-90	<-90	<-90	<-90	<-90
Glass Transition Temperature (Tg)	(DMA)#	°F	-44	-22	-33	-40	-51	-29	-15	3
Vicat Softening Temperature: Rate A	D 1525	°F	196	190	246	248	316	293	349	295
FLAMMABILITY†										
UL94 Flame Class: 0.062-in (1.57-mm) Thickness	(UL94)	Rating	HB[a]						HB[b]	

* These items are provided as general information only. They are approximate values and are not part of the product specification.
** Postcured 16 hrs. at 230°F (110°C).
\# DMA: Dynamic Mechanical Analysis.
† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.
[a] Natural color.
[b] Natural and black colors.

TEXIN AND DESMOPAN THERMOPLASTIC POLYURETHANE

Texin Thermoplastic Polyurethane (continued)

Polyester		Polyether			Polyurethane/Polycarbonate Blends						Medical			
360-D	470-D	985-A	990-A	970-D	3203	4203	4206	4210	4215	3215	5286	5187	5265	5370
1.23	1.24	1.12	1.13	1.18	1.22	1.21	1.21	1.21	1.21	1.21	1.12	1.20	1.17	1.21
60 D	70 D	86 A	90 A	70 D	60 D	60 D	65 D	70 D	75 D	75 D	86 A	87 A	65 D	70 D
55	90	30	25	75	90	70	80	65	85	80	30	15	75	65
42	55	45	40	50	40	42	46	45	52	55	45	45	50	45
0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.006	0.008	0.008	0.008	0.008
0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.006	0.008	0.008	0.008	0.008
•	•	• • • • •	• • • • •	• • •	•	• •	• •	• •	• •	•	• • • • •	• • • • •	• • • •	• • •
5,000	6,000	6,000	5,000	6,000	4,500	5,000	5,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
2,400	4,100	650	950	2,500	2,700	2,500	3,700	4,100	4,600	4,800	650	720	2,900	4,100
2,700	4,300	700	1,000	3,000	3,300	2,700	4,000	4,500	5,300	5,200	700	750	3,300	4,500
3,400	5,200	1,100	1,750	5,200							1,100	1,700	4,450	
500	350	550	550	375	300	325	200	180	150	175	550	500	460	180
30,700	105,000	3,900	6,000	55,000	31,000	30,000	60,000	100,000	150,000	150,000	3,900	4,000	55,000	100,000
20 (15)	50 (30)	19 (16)	20 (13)	40 (25)							19 (16)	16 (12)	28 (20)	
40 (25)	85 (45)	80 (40)	75 (35)	75 (45)							80 (40)	65 (35)	88 (35)	
						3,920	5,300	6,200	7,300					
1,000	1,300	500	550	1,100	750	850	800	900	950	1,000	500	500	1,200	900
					13	13	13	16	18	15				
						1	1	1	1.5					
					42.0	44.1	33.1	35.8	39.1	36.0				
					41.0	40.9	39.6	40.5	42.9	44.0				
				113	114	99	109	139	166	183				139
133	115			155	144	131	150	208	227	231				208
7.2 E-05	5.5 E-05			6.4 E-05		7.0 E-05	5.8 E-05	5.7 E-05	5.0 E-05	8.9 E-05				5.7 E-05
<-90	<-90	<-90	<-90	<-94	<-90	<-90	<-70	<-90	<-90	<-90	<-90	<-90	<-90	<-90
-20	32	-51	-47	32	-11	-27	-27	-31	-31	0	-51	-44	14	-31
315	316	176	223	306	302	295	286	282	284	295	176	197		282

BAYFLEX ELASTOMERIC POLYURETHANE RIM

Bayflex
Elastomeric RIM

THERMOSETS Typical Physical Properties	[illegible]	[illegible]	MP-5000	MP-10000	110-25 IMR	110-50		XGT-100	
			Unfilled	Unfilled	Unfilled	Unfilled	15% Glass[1]	Unfilled	15% Glass[1]
GENERAL									
Specific Gravity	D 792		1.0	1.0	0.98	1.04	1.15	1.04	1.15
Density	D 1622	lb/ft³	62.4	62.4	61.2	63	71.2	65	72
Thickness		in	0.118	0.118	0.125	0.125	0.125	0.125	0.125
Shore Hardness	D 2240	A or D	30 D	40 D	50 D	58 D	60 D	69 D	70 D
Mold Shrinkage	(Miles)	%	1.25	1.4	1.4	1.4	0.5-0.6	0.75-0.85	0.55-0.75
Water Immersion, Length Increase	(Miles)	in/in	0.015	0.014	0.008	0.006	0.002		
Water Absorption:	(Miles)								
24 Hours		%	3.3	3.3	2.8	2.8	2.6		
240 Hours		%	5.0	5.0					
MECHANICAL									
Tensile Strength, Ultimate	D 638/D 412	lb/in²	1,900	2,200	3,000	3,200	2,900	4,000	4,100
Elongation at Break	D 638/D 412	%	360	300	260	220	93	100	50
Flexural Modulus:	D 790								
149°F		lb/in²	4,000	7,900		38,000	60,000	43,000	94,000
73°F		lb/in²	5,000	10,000	25,000	51,000	100,000	100,000	210,000
-22°F		lb/in²	14,500	23,600		115,000	160,000	200,000	403,000
Flexural Strength	D 790	lb/in²	230	240	350	440	570	670	700
Tear Strength, Die C	D 624	lbf/in					[illegible]	[illegible]	[illegible]
Compressive Strength	D 395	lb/in²							
Impact Strength:									
Charpy Impact		ft-lb/in²			8	11	8	9	4.3
Notched Izod	D 256	ft-lb/in					[illegible]	[illegible]	[illegible]
Unnotched	D 256	ft-lb/in							
THERMAL									
Deflection Temperature Under Load:	D 648								
264 psi		°F					[illegible]	[illegible]	[illegible]
66 psi		°F							
Heat Sag:	D 3769								
6-in Overhang, 1 hr at 250°F		in			0.51	0.60	0.28		
4-in Overhang, 1 hr at 250°F		in				0.36	0.27	0.67	0.24
Coefficient of Linear Thermal Expansion	D 696	in/in/°F				78 E-06	44 E-06	58 E-06	28 E-06
FLAMMABILITY†									
UL94 Flame Class:	(UL94)								
0.125-in Thickness		Rating					[illegible]	[illegible]	[illegible]
0.250-in Thickness		Rating							

* These items are provided as general information only. They are approximate values and are not part of the product specifications.
† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.
[1] Milled glass fiber, OCF 737, 1/16 inch.
[2] Directed chopped fiber preform.
[3] Continuous strand mat.

Note 1
All directional properties are listed parallel to flow.

Note 2
IBS: Interactive Blowing System.
IMR: Internal Mold Release.
RIM: Reaction Injection Molding.
XGT: Extended Gel Time.

BAYDUR STR COMPOSITE POLYURETHANE RIM
BAYDUR STRUCTURAL FOAM POLYURETHANE RIM
PRISM SOLID POLYURETHANE RIM

Baydur STR Composite RIM		Baydur Structural Foam RIM							PRISM Solid RIM	
STR/C-400 BB	STR/F-350 IMR	D-15	660 IBS		730 IBS		726 IBS		CM-200	
60% Glass*	17% Glass*	Density 20 pcf	Density 25 pcf	Density 35 pcf	Density 35 pcf	Density 41 pcf	Density 40 pcf	Density 55 pcf	Density 61 pcf	Density 67 pcf
1.71	0.50	0.32	0.40	0.56	0.56	0.66	0.66	0.80	0.98	1.07
107	32	20	25	35	35	41	40	55	61	67
0.160	0.125	0.500	0.500	0.500	0.250	0.250	0.250	0.250	0.125	0.125
		40 D	57 D	70 D	65 D	70 D	66 D	81 D	73 D	75 D
					0.7-0.9	0.7-0.9	0.7-0.9	0.7-0.9	0.7-0.9	0.7-0.9
0.05	0.10									
0.35										
0.98										
32,100	2,900	1,000	1,300	2,800	2,000	2,700	3,100	4,800	5,500	6,600
1.8		6	7	7	10	10	8	8	11	12
2,120,000	220,000	53,000	76,000	113,000	125,000	170,000	160,000	240,000	267,000	309,000
62,600	6,700		3,000	5,000	4,000	5,500	5,600	9,000	9,300	10,300
		900	1,200	2,600						
		2.2	4.8	6.3	8.2	11	8	15		
30.7	6.5								5	7
416	209	149	199	219	158	176	181	212	192	205
	0.04								0.29	0.26
7.8 E-06	7.8 E-06									
							V-0/5VA	V-0/5VA	V-0/5VA	V-0/5VA

BAYTEC RE POLYURETHANE SPRAY SYSTEMS
BAYTEC RTM POLYURETHANE SYSTEMS FOR RESIN TRANSFER MOLDING

THERMOSETS Typical Physical Properties			Baytec RE Spray Systems					Baytec RTM Molding Systems		
			RE 526		RE 832	RE 527		RTM 532		
			Unfilled	30% Mineral[1]	Unfilled	Unfilled	7% Glass[2]	Unfilled	20% Glass[3]	40% Glass[3]
GENERAL										
Specific Gravity, 77°F	D 792		1.05	1.11	0.96	1.16	1.2	1.18	1.28	1.44
Density, 77°F	D 792	lb/ft³	66	69	60	72	75	74	80	90
Shore Hardness	D 2240	A or D	86 A/38 D	65 D	66 A	75 D	80 D	81 D	82 D	84 D
Taber Abrasion:	D 4060									
H-18 Wheel, 1000-g Load, 1000 Cycles		mg Loss	217	908	350					
Bayshore Resilience	D 2632	%								
Mold Shrinkage	(Miles)	%				1.1	0.4	2	0.12	0
Processing Methods:										
• Casting			•	•	•			•	•	•
• Spray			•	•	•	•	•			
• Resin Transfer Molding								•	•	•
Paintable •			•	•	•	•	•	•	•	•
MECHANICAL										
Tensile Strength	D 412	lb/in²	750	1,070#	900	7,000	8,000	7,200#	14,500#	25,000#
Tensile Stress at 100% Elongation	D 412	lb/in²			320					
Tensile Stress at 200% Elongation	D 412	lb/in²			460					
Tensile Stress at 300% Elongation	D 412	lb/in²			600					
Ultimate Elongation	D 412	%	65	50#	490	6	4	8#	4#	4#
Flexural Strength: 77°F	D 790	lb/in²				10,200	12,400	11,300	22,000	35,000
150°F		lb/in²						3,700	12,900	20,500
Flexural Modulus: 77°F	D 790	lb/in²		7,100		287,000	403,000	300,000	650,000	1,000,000
150°F		lb/in²						105,000	400,000	740,000
Shear Strength, Compressive Lap:	D 3846									
Polyurethane - Acrylic		lb/in²				>2,000	>2,000			
Polyurethane - ABS		lb/in²				>4,000	>4,000			
Compression Set:	D 395-B									
22 Hours at 158°F		%								
Compression Deflection: 5%	D 575	lb/in²			50					
10%		lb/in²			90					
25%		lb/in²			210					
Tear Strength: Die C Tear	D 624	lbf/in	120		180					
Split Tear	D 1938	lbf/in	50		90					
Impact Strength, Notched Izod:	D 256									
0.125-in Thickness, 77°F		ft-lb/in				0.5	1.5	0.6	6	10
Instrumented Impact, Total Energy:	D 3763									
0.100-in Thickness, 77°F		ft-lb		1.9		0.31	3.5	0.2	6	10
THERMAL										
Deflection Temperature Under Load:	D 648									
264 psi		°F						130	260	390
66 psi		°F				122	138	160	420	>425
Coefficient of Linear Thermal Expansion, 122°F	(Miles)	in/in/°F				41 E-06	17 E-06	43 E-06	9 E-06	7 E-06
FLAMMABILITY†										
UL94 Flame Class at 0.125-in Thickness	(UL94)	Rating				HB	HB			
ANSI Z-124.1, 5.6 (1987)	(ANSI)	Rating		Pass		Pass	Pass			
ANSI C37.20.2, 5.2.7	(ANSI)	Rating		Pass	Pass					
ELECTRICAL										
Dielectric Strength	D 419	V/mil	322		366					
Arc Resistance	D 495	s	121	122	123					

* These items are provided as general information only. They are approximate values and are not part of the product specifications.
† Flammability results are based on small-scale laboratory tests for comparison purposes only and do not necessarily represent the hazard presented by this or any other material under actual fire conditions.
# Tested in accordance with ASTM D 638.
[1] Calcium carbonate.
[2] 0.250-inch chopped fiberglass roving.
[3] Continuous strand mat.

Note 1
All cast elastomer properties refer to uncatalyzed and postcured materials (postcured for 16 hours at 230°F/110°C).

Note 2
PTMG: Poly(tetramethylene ether) glycol
PG: Poly(propylene ether) glycol

BAYTEC POLYURETHANE PREPOLYMERS FOR CAST ELASTOMERS

Baytec
Prepolymers (Cured with 1,4-Butanediol)

PTMG				PG		Polyester						
ME-040	ME-050	ME-080	ME-090	MP-090	MP-100	MS-041	MS-051	MS-061	MS-081	MS-090	MS-092	MS-242
79 A	85 A	93 A	95 A	85 A	90 A	72 A	80 A	87 A	90 A	93 A/47 D	93 A/43 D	85 A
12	15	20	25	90	84	10	16	24	26	38	30	30
65	63	60	60	20	20	52	52	44	44	26	43	32
•	•	•	•	•	•	•	•	•	•	•	•	•
4,200	4,600	5,100	5,400	5,000	4,800	5,100	5,360	6,500	6,600	7,500	6,870	7,150
600	840	1,150	1,560	990	1,640	460	640	900	1,110	1,500	1,480	830
940	1,150	1,500	2,000	1,580	2,750	620	870	1,250	1,500	2,590	1,960	1,215
1,200	1,670	1,900	2,600	2,750	4,290	820	1,180	1,730	2,350	3,800	2,600	1,750
480	480	490	500	410	315	560	525	525	500	480	510	575
17	16	18	17	45	35	20	24	18	20	35	22	24
140	180	250	320	130	165	70	105	160	220	310	275	170
180	370	490	575	275	360	145	220	280	425	600	530	300
520	885	1,090	1,180	750	1,080	410	570	680	930	1,350	1,200	740
340	415	555	610	360	380	325	380	550	575	705	675	525
80	90	100	140	90	90	100	105	175	200	400	275	300

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Polyurethane Handbook

Chemistry – Raw Materials – Processing
Application – Properties

Edited by Günter Oertel

2nd Edition

With contributions from

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Preface

Since its publi
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February 1993

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= tin cat., d = amine cat.

; PUR catalysts:

manufacture of flexible
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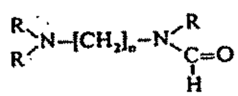
Table 3.9. Relative Activity as a Function of Concentration and Synergism of Typical Commercially Used Catalysts [2]

Catalyst	Concentration %	Relative reactivity
uncatalyzed	–	1
TMBDA	0.1	56
DABCO	0.1	130
TMBDA	0.5	160
DBTL	0.1	210
DABCO	0.2	260
DABCO	0.3	330
SnOct	0.1	540
DBTL	0.5	670
DBTL + TMBDA	0.1 + 0.2	700
SnOct + TMBDA	0.1 + 0.2	1000
DBTL + DABCO	0.1 + 0.2	1000
SnOct + TMBDA	0.1 + 0.5	1410
SnOct + DABCO	0.1 + 0.5	1510
SnOct	0.3	3500
SnOct + DABCO	0.3 + 0.3	4250

TMBDA = Tetramethylbutanediamine
DABCO = 1,4-Diaza(2,2,2)bicyclooctane
DBTL = Dibutyltindilaurate
SnOct = Tinoctoate

Further, polyamines partially neutralized with formic acid [10] have attained significance as delayed action catalysts for semirigid and flexible molded foams. In recent years, a new latent catalyst was described that is noncorrosive and nonvolatile (no smell). The basis is the chemically blocking of the active amine by a component whose structure was not disclosed [11]. The product is used for flexible and semirigid foam.
Because of industrial hygiene concerns, the N-acylated amines [12] as low odor catalysts are of interest for foam manufacture:



All terms and measuring procedures for the simple description of the kinetics of the polyurethane reaction are derived from industrial practice and observations of macroscopic phenomena. They are based on the following steps as a function of time:

- Mixing time (stirring time) is the duration of the time of mixing the components.
- The cream time (gel time, start time) is the time lapse from the beginning of the mixing process until a visual change or a distinct rise in the viscosity and the volume of the reaction mixture occurs.
- The rise time (only for foams) is the time span from the beginning of mixing to the end of the rise of the foam.
- The setting time (curing time) is the time span from the beginning of mixing until a point is reached where the polyaddition product no longer flows. According to the working procedure and the product, the determination of the setting time follows different criteria. Figure 3.4 shows that the reaction is not at all finished within the set time. Only a fraction of the total reaction rate is described by the described times. The complexity of the course of reaction is best described by the variety of terms used in practice, i.e., "post-pressure time", "tack free time", "string time", "pluck time".

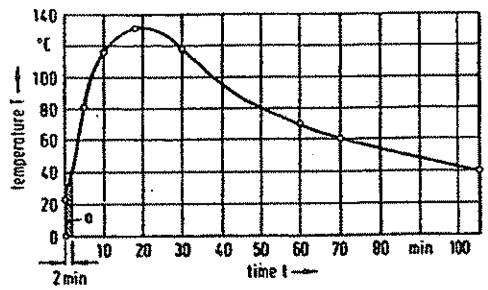


Fig. 3.4. Accessible measurable range of a specific application of a PU reaction (example: 275 g preparation of PU rigid foam, apparent density 22 kg/m³) a = area between stirring dand tack-free time

- The mold release time is the time span from the mixing of the components until the earliest possible removal of the finished part ("green strength"). Cycle time is greater than the molding process time and includes mold preparation and post treatment (cleaning, mold release agents and taking out parts).
- Final curing time is the time span until the final curing of the finished part. This will be widely different based on the product and process (hours, days weeks) as well as temperature and humidity effects (compare section 5).

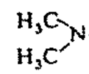
3.4.1.2 Catalysis for NCO/NCO Reactions

The catalysis for dimerization to uretdiones, the carbodiimide formation, and the currently less important linear polymerization of isocyanates to polyamide-1 has already been described in subsection 2.1.2.2 and 3.3.2.2. The trimerization reaction for the manufacture of solid and cellular polyurethanes has far greater significance.
Isocyanurate structures give polyurethanes a higher heat resistance and improve intrinsic fire retardance. Since pure polyisocyanurates lead to very brittle products, in practice PIR/PUR combinations are used exclusively [13]. As a result, two reactions running concurrently must be catalytically controlled: the NCO/OH and the trimerization reaction. In this regard, the catalysts for the isocyanurate formation have been thoroughly investigated [13 to 16]. In Table 3.10 the trimerization catalysts are collected according to structural types.

Table 3.10. Typical Structures of Trimerization Catalysts

$R^1R^2R^3N$	Amines
R_3P	Phosphines
R–OMe (Me = z. B. Alkali)	Alcoholates
Me_xO_y	Metal oxides
RCOOMe Me = K, Na, Ca, Fe, Mg, Hg, Ni, Pb, Co, Zn, Cr, Al, Sn, V, Ti	Carboxylates
R–Me– Me = Zn, Si, Sn, Pb, Sb R_2Me R_3Me	Organo metal compounds
	Metal-Chelates
	Hydrides
org., inorg., Lewis-acids	Acids
Amine-epoxides Amine-alkylenecarbonates Amine-imides	Combined catalysts

From this schema



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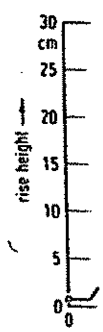

In flexible foams.
amine/tin catalysts

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